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Pre-Feasibility Study Report of Mid-Hill Lift Irrigation Project (Package 6)

Prepared by K. R. Gautam; P. R. Pande; R. Paudel and A. B. Pradhan

Kathmandu, Nepal

For: Ministry of Irrigation
Department of Irrigation, Kathmandu
Department of Water Induced Disaster Prevention

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Asian Development Bank

Government of Nepal
Ministry of Irrigation
Department of Irrigation

ASIAN DEVELOPMENT BANK

Water Resources Project Preparatory Facility

Package 6- Pre-Feasibility Study Report
of
Mid-Hill Lift Irrigation Project

Final Report

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Submitted by:

- Pradip Raj Pande, Team Leader
- Ram Chandra Paudel, Electrical Engineer
- Abhishek Bahadur Pradhan, Civil Engineer
- Kamal Raj Gautam, Agro-Economist

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Study Team

Pradip Raj Pande, Team Leader
Ram Chandra Paudel, Electrical Engineer
Abhishek Bahadur Pradhan, Civil Engineer
Kamal Raj Gautam, Agro-Economist

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Abbreviation and Acronyms

ADB	:	Asian Development Bank
ADBN		Agricultural Development Bank, Nepal
ADS	:	Agriculture Development Strategy
APP	:	Agricultural Perspective Plan
CMIASP:		Community Managed Irrigated Agriculture Sector Project
D0I	:	Department of Irrigation
DADO	:	District Agriculture Development Office
DHM	:	Department of Hydrology and Meteorology
DoA	:	Department of Agriculture
DoLIDAR:		Department of Local Infrastructure Development and Agricultural Roads
EIA	:	Environmental Impact Assessment
EPA	:	Environmental Protection Act
EPR	:	Environmental Protection Regulation
FAO	:	Food and Agriculture Organization
FGD	:	Focus Group Discussion
G0N	:	Government of Nepal
GIS	:	Geographical Information System
GPS	:	Global Positioning System
Ha/ ha	:	Hectare
HH	:	Households
HLP	:	High Lift Pump
IEE	:	Initial Environmental Examination
IP	:	Irrigation Policy
IWR	:	Irrigation Water Requirement
IWRMP:		Integrated Water resources management project
KII	:	Key Informant Interaction
kV	:	kilo Volt

kW	:	kilo Watt
LMC	:	Lower Main canal
lps	:	Liter per second
MM	:	Millimeter
MoI	:	Ministry of Irrigation
MW	:	Megawatt
NEA	:	Nepal Electricity Authority
NITP	:	Non-Conventional Irrigation Technology Project
NPC	:	National Planning Commission
NWP	:	National Water Plan
O & M	:	Operation and Maintenance
PMO	:	Project Management office
ToR	:	Terms of References
VDC	:	Village Development Committee
WECS	:	Water and Energy Commission Secretariat
WRPPF	:	Water Resources Project Preparatory Facility
WRS	:	Water Resources Strategy
WUA	:	Water Users Association

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Executive Summary

1. For agricultural development, Department of Irrigation has been implementing small, medium and large irrigation projects in the hills and Terai areas of the country. Several river terraces in the lower and mid hills along the big river corridors are still dependent on monsoon rainfall. The only possibility of irrigation in these river terraces would be pumping of water from the river courses running parallel to the terraces, provided the head of pumping is not large and dependable energy sources are available locally. In this context, The Asian Development Bank (ADB) and the Government of Nepal (GoN) are supporting “Water Resources Project Preparation Facility (WRPPF)” to identify and prepare high priority water resources management projects for potential funding of GoN with the assistance from ADB and/or other funding sources. Lift Irrigation Project in Mid Hills has been identified as one of the high priority project to study for future implementation of this project. WRPPF is proposing to conduct pre-feasibility level of study of mid-hill lift system in Kali Gandaki, Marsyangdi and Daraundi River Basins or alternatively more potential basin. It is therefore the present study is proposed and being undertaken.

2. The overall objective of this assignment is to identify the potential locations (river terraces) for pumping lift irrigation schemes in Kali Gandaki, Marsyangdi and Daraundi River basins or alternatively other potential basin with sizable irrigation coverage and possibility of year round irrigation coverage and to prepare pre-feasibility report of mid-hill lift system based on technical and financial grounds.

3. The river water is flowing at a level below the study area level. The water needs to be lifted by using electrical pump for irrigation. The proposed irrigation development plan considers the introduction of lift irrigation technology and diversification of irrigated agriculture.

4. The study area lies on Kaligandaki, Marsyangdi and Daraundi Basin in Palpa, Syangja, Tanahun, Lamjung and Gorkha Districts. All the areas have road access. The climate of the area is sub-tropical with two distinct seasons, the dry season and wet season. Agro-climatic conditions are suitable for cultivating sub-tropical crops including vegetables.

5. Altogether 55 schemes were primarily studied by the team in Kaligandaki, Marsyangdi, Daraundi and Madi Basins. Based on the developed criteria the team assigned score against the various indicators. Reviewing the scores, the schemes were placed on clusters. The first three clusters having highest scores are proposed for further study. Other clusters 4 to 11 are to be considered in future. These three clusters are- Madinadi 1, Marsyangdi 1 and Kaligandaki 1. These clusters have seventeen systems.

6. For the Pump and pipe designs, Chyangli lowland, Chyangli Highland, Baireni (Kumaltari) and Aanpchaur tars are taken as models of different heads (lower to high heads).

7. The study area comprises the Hill ecological region slopping towards river. The area is stretched along the lower terraces of the river basins. Irrigation from the rivers in the project area is not possible with conventional technology.

8. The major ethnic groups in the area are Kumals, Magar, Brahmin, and Chhetri. Agriculture is the primary occupation in the study area. Most of the farmers are small farmers. The existing agriculture is dependent mostly on rain-fed irrigation. The existing cropping intensity is 108 % which indicates the necessity for irrigation development.

9. Intake structure, pumps, electrical systems, water collection reservoir, pump house, and distribution network are the major components of the project. It is also proposed to use solar power as alternative to national electric power supply grid. The proposed cropping intensity for lift irrigation is 253.14 %

10. In the Study, the solar system is proposed as an alternative power source. If farmers prefer to go for solar system, its cost is provisioned in the Study.

11. Based on the environmental assessment, the project is environmentally sound and therefore supports the long term sustainability.

12. The detailed estimates for the designed Chyangli lowland, Chyangli Highland, Baireni (Kumaltari) and Aanpchaur tars are prepared. Head vs. cost per hectare graph is prepared for both with or without solar power. Equations are developed for Head and cost per hectare relationship. Based on these equations, the cost of each system in each cluster is calculated for both the cases (with or without solar). The overall cost of the project is obtained.

13. The construction cost of the project is computed based on district rates and the government norms. The project agricultural benefits are assessed with the consideration of proposed cropping patterns and inputs to be adopted by farmers. The economic analyses of these projects are carried out considering 30 years' lifetime. Benefit cost analysis is carried out for Madi 1, Marsyangdi1 (Chyangli High land and Chyangli Low land), Kaligandakai and the whole project area. The major facts about the project is given below:

    - Total Gross Command Area =1366 hectares
    - Total Cost =NRs.62, 84, 89,000 without solar system and NRs. 1,121,230,000 with solar system
    - In normal case the BC Ratio is 3.69 and EIRR is about 35.63%.
    - Sensitivity analysis with the case of 20% cost increments BC Ratio is 3.02 and EIRR is about 30.73%. In the same way if benefit is decreased by 20% BC Ratio is 2.95 and EIRR is about 30.45%.
    - In the case of cost increments by 20% and benefit is decreased by 20% BC Ratio is 2.46 and EIRR is about 26.62%.

14. It is recommended to conduct Detail Feasibility Study of these three clusters as early as possible. Then the implementation of the project be taken up as planned in the Implementation schedule of this Report.

1.0 INTRODUCTION

1.1 Background of the Study

1 Irrigation has been practiced in Nepal since historical days. Since the time immemorial, Nepalese farmers, both in the hills and terai regions have been successfully diverting the river water to irrigate their agriculture land. Chandra Canal constructed in (1922 -1928) can be regarded as the first step towards developing a system having planned infrastructures. In 1952, Department of Irrigation was established to institutionalize irrigation activities. Irrigation infrastructure development received priority only after 1957, the milestone of the beginning of periodic plan in Nepal. According to one estimate[1], there were more than 12,000 irrigation systems partially irrigating about 0.4-0.5million hectares of land prior to 1957.Similarly multi-lateral donor agencies like the World Bank and the ADB came forward for providing assistance in irrigation development of Nepal. Realizing the vital role of irrigation to enhance agricultural production, Department of Irrigation (DoI) has been implementing several small, medium and large irrigation projects in the hill and Terai regions.

2 Based on the prevailing irrigation water use policy documents, Water Resource Act 2049, National Water Resource Strategy 2002, National Water Plan 2005 and Irrigation Policy 2070, the Government lately has accorded priority to the development of new irrigation projects and O&M of developed schemes with participation of Water Users' Associations. Similarly, since the last few years, government agencies have been working with marginalized farmers in remote areas under the program of Non-Conventional Irrigation Technology Project (NITP). Having realized the importance of year round irrigation, Government is planning to start multipurpose inter basin water transfer project, diverting water from water surplus river to water deficit river and Bheri Babai diversion project is the first one to be implemented. At present, Sikta, Ranijamara Kulariya, Mahakali III, Babai, IWRMP, CMIASP and Medium Irrigation Project (MIP) are few examples of major projects under implementation. Recently, the government is planning to use lift irrigation technology to irrigate river valley terraces along the big rivers in mid hills. Out of the total 14.718-million-hectare area of the country only 2.641-million-hectare area is arable and 1.766-million-hectare land is irrigable. Irrigation infrastructures development covers about 1.336 million hectares.

3 Most of the developments of irrigation infrastructures in Nepal have been limited to Terai and Hill River Valleys. The main reasons for these areas receiving high priority are-availability of more dependable irrigation source, technically more feasible locations for river abstraction and possibility of sufficient irrigation coverage. The river terraces in the lower and mid hills, which encompass sizable arable lands, have been left out on the ground of one or more technical and financial limitations relating to the source, topography and availability of potentially suitable of sites for developing river diversion or storage works. These areas also lack groundwater potential for dependable irrigation. The only possibility of irrigation in the river terraces would be pumping of water from the river courses running

[1] DOI: Sinchai Barshik Pustika 2013-14

parallel to the terraces, provided the head of pumping is not large and dependable energy sources are available locally to support pumping lift system to bring sizable area of land under year round irrigation.

4 The Asian Development Bank (ADB) and the Government of Nepal (GoN) are supporting "Water Resources Project Preparation Facility (WRPPF)" to identify and prepare high priority water resources management projects for potential funding of GoN with the assistance from ADB and/or other funding sources. Lift Irrigation Project in Mid Hills has been identified as one of the high priority project to study for future implementation of this project.

5 Huge energy cost, more frequent breakage and wear and tear of electro-mechanical components and unwillingness of the farmers to share the operation and management costs have been the key constraints to dependable irrigation services in the earlier developed lift irrigation schemes in the country - Battar Lift Scheme, Narayani Lift Irrigation, Koshi Pump Canal and Marchwar Lift Irrigation. Considering these constraints, lift irrigation schemes in the river terraces in the lower and mid hills having sizable arable lands could not receive priority for development. Now to increase the agricultural productivity in these areas, irrigation development activities in these river terraces have to be conducted. Lift irrigation system may be one of the solutions depending on the technical and financial viability. "Water Resources Project Preparation Facility (WRPPF) is proposing to conduct pre-feasibility level of study of mid-hill lift system in Kali Gandaki, Marsyangdi and Daraundi River Basins or alternatively more potential basin. It is therefore the present study is proposed and being undertaken.

1.2 Objective and Scope of the Study

6 The overall objective of this assignment is to identify the potential locations (river terraces) for pumping lift irrigation schemes in Kali Gandaki, Marsyangdi and Daraundi River basins or alternatively other potential basin with sizable irrigation coverage and possibility of year round irrigation coverage and to prepare pre-feasibility report of mid-hill lift system based on technical and financial grounds.

7 The specific objective of the study is: to complete pre-feasibility level study of three mid-hill pumping lift system with the aim of evaluating technical, economic and financial pre-feasibility of energy and technology options for year round irrigation coverage. The findings of the study would develop grounds for detailed feasibility study of selected systems and extending the initiative of development of pumping lift irrigation systems to other river basins/sub-basins in the due course.

8 In order to achieve the said objectives, the study will focus on field level observations and assessment of potential lift irrigation projects against the stated criteria. The scope of the work is broadly

- Identify potential locations in Kali Gandaki, Marsyangdi and Daraundi River Basins or other potential basin suitable for the development of pumping lift for schemes to bring sizable area under year round irrigation.
- Establish the options of power sources and their suitability and cost implications for the proposed mid-hills pumping lift scheme.
- Assess existing Cropping System and Practices and the Changes with the Proposed Development.
- Establish the hydrologic design parameters - the collection, analysis and synthesis of hydro-meteorological data relevant to the study area.
- Prepare design of system components- choices of technology and infrastructure for intake, storage, the pumping system, pump house, water conveyance and distribution system, power generation (in the case of need for solar farm) and transmission system based on the water needs in the system and the supply and the site characteristics.
- Identify the environmental impacts (positive and negative) emerging from the proposed development and identifying the mitigation measures would be required for pre-feasibility study.
- Propose an appropriate institutional arrangement for operation and maintenance of the system and in organizing the users into a water users' association (WUA).
- Give focus on social safeguards at the prefeasibility level ensuring inclusion of socially and economically disadvantaged groups- women, landless, dalits and ethnic minorities in the project.
- Estimate the investment needs involving the proposed development and projection of benefit streams to develop the cash flow- a preliminary economic and financial analysis of the 3 sub-projects.
- Propose an indicative project implementation plan.

1.2 Approach and methodology of prefeasibility assessment

1.2.1 Approach

9 The approach of the study work in general consisted of - collection of data and information from various sources, appropriate coordination among the members of the study team and with the project authorities, desk study of Google earth maps, plan, policies, and hill irrigation practices of the Government, field visit and survey and investigation with a team of multidisciplinary team, and analysis of data and information including its interpretation.

1.2.3 Methodology

10 Secondary and primary Information collection and analysis method is used during the project pre-feasibility assessment process.

11 The consultants collected and reviewed available information on the lift irrigation in Nepal and other countries. The consultants reviewed, analyzed and synthesized relevant secondary sources of information pertinent to mid-hill pumping lift irrigation scheme in Kali Gandaki, Marsyangdi and Daraundi River basins and those pertinent to the potentially suitable locations, including physiography and geological characteristics of the area, socio-economic context, hydro-meteorological characteristics, performance of agricultural systems and practices. Information was updated and compiled in a brief profile of candidate schemes.

12 During initial phase of study, the field study programs and procedures were prepared for this, the detailed checklist of the jobs to be carried out for fieldwork has been prepared

- Focus Group Discussion (FGD) and Key Informants interaction (KII)

13 The project officials, DoI officials, Directorate officials in Western Region for irrigation and agriculture development, District agriculture development officer, lead farmers and general water users were consulted by the concerning team members with the help of questionnaire prepared during inception. The discussion primarily focused on the possibility of lift irrigation in study area.

Photo 1 KII at Chayangli

14 PRA/RRA Method: Group discussions with local farmers in various locations were held. This helped the team to obtain the data relating on socio-economic, water requirement and availability, water allocation and distribution aspects.

- Observation

15 The study team has made observation wherever needed. Concerned experts have prepared complete inventories of the study area starting with the existing irrigation facility, agricultural practices, and availability of water for irrigation. The other parameters such as cropping pattern, cropping intensities, and water source reliability, etc. were assessed. It was also noted if any irrigation system was in operation in the concerned area. List of consulted personal and agencies is presented in Annex-1

Photo 2 Observation of Agri farm at Tanahu

1.2.3 Data Analysis, interpretation and Report Preparation

16 The data collected during fieldwork as well as the secondary information collected during inception and report preparation phase were analyzed in line with the project objective. The results obtained from analysis have been synthesized and possibilities for lift irrigation development have been identified.

1.3 Frame and Structure of Report

17 The report has 12 sections starting with the introduction. In the second section Overview of Lift irrigation development, systems and agencies involved in its development are described while the third section of the report deals with the lift irrigation scheme areas. Selection procedures and selection of schemes are discussed and analyzed with its location, accessibility, climate and topography with land use. The hydrology and water resource assessment for irrigation of potential area is given in fourth section. The agricultural situation of the study area and the proposed plan of development for agricultural enhancement are highlighted in the fifth section. Sixth section deals with socio economic profile and social safeguard of the study area. The seventh section deals with the proposed irrigation development plan. The proposals for project implementation with its organization structure and schedule are described in eighth section. The environmental guidelines for irrigation development and assessment of the initial environmental examination are briefed in ninth section. In tenth section power supply system with alternative of solar power and its cost and O&M are discussed. The cost of the project including its economic evaluation is included in the eleventh section. Conclusions and recommendations of the study findings are described in the last section. Separate Annexes for relevant matters are also part of the report.

1.4 Analysis of data and report preparation

18 The consultants have tried to ensure a high level of data reliability and validity of conclusions by combining various methods and techniques. Data collected through different means were thoroughly cross-checked, i.e. collected information were further checked and verified with the district Division and Agricultural Development offices. Data derived through group discussions were further verified interviewing with individual farmer. Personal perceptions, opinion and observations were also recorded and used during the analysis. The initial draft report was shared with the WRPPF and the comments, suggestions were duly incorporated.

2.0 OVERVIEW OF LIFT IRRIGATION DEVELOPMENT IN NEPAL

2.1 Plans and policies for irrigation

2.1.1 Water Resources Act-1992

19 The Water Resources Act-1992 is an umbrella Act of water sector. It has fixed an order of priority for the use of water resource. According to the Act the first priority is for drinking water while irrigation and agricultural uses are second and third priorities. Similarly, hydro -electricity comes to the fourth priority followed by cottage industries, water transportation and recreational uses. The Act states that State has the ownership of water; which is not transferable. But the right to use is conferred by way of licensing while no license is required for individual and collective use of water within the community. This Act recognizes water users' organizations as the autonomous corporate entity with a right to perpetual succession. The act enables the government to transfer government-administered irrigation systems to farmer-ownership and management. It also provides the provision of involvement of non-governmental organizations in small-scale and even in large-scale irrigation development and management.

20 Water Resources Rules, 1993 has detailed out most of the procedures required to make the Water Resources Act effective.

2.1.2 Agricultural Perspective Plan 1995

21 The first long-term Agriculture Perspective Plan (APP) was developed in 1995, which aimed to focus agricultural development through four strategic inputs as irrigation, fertilizer, infrastructure development, and technology. In irrigation. APP emphasized on the development of small and medium irrigation systems in the hills for high value crop production. The APP became a plan with a mixed performance. In some cases, its targets were achieved, such as in roads, horticulture and community forest; however, in the case of cereals, fertilizer, and seed the performance was poor; in the case of livestock and irrigation the performance was mixed; and overall agricultural GDP growth was weak. The APP formulation was based on a narrow view of technology excessively focused on a green revolution perspective that is not appropriate for large parts of Nepali agro-ecology. APP implementation was poor because of limited support in terms of resources, policies, and institutions needed to carry out its program. APP ownership was weak and the leading stakeholders of the agricultural sector – farmers, private sector, cooperatives – were not actively involved in its formulation and implementation. Land issues were left unresolved.

2.1.3 Agriculture Development Strategy, 2014

22 The ADS is expected to guide the agricultural sector of Nepal over the next 20 years (2016-2035). Over the course of this period, the structure of the agricultural sector in Nepal will change considerably and agribusiness and non-farm rural activities will grow relatively to agriculture. Strengthened linkages between agriculture and other sectors in the economy will be critical to the reduction of poverty particularly in rural areas where the development of non-farm activities based on agriculture will be fundamental for the growth of an overall robust economy, a more balanced rural economy, and employment generation. In this context, it is worth emphasizing that the ADS considers the agricultural sector in its complexity, and encompasses not only the production sectors (crops, livestock, fisheries, forestry) but also the processing sector, trade and

other services (storage, transportation and logistics, finance, marketing, research, extension). The ADS is formulated taking into account the conceptual framework of agricultural transformation of Nepal from a society primarily based on agriculture to one that derives most of its income from services and industry. This process will have profound implications for the ways the Nepali population will shape their food production and distribution systems, the development of rural areas including the rural non-farm sector, labor and land productivity, trade balance, employment and outmigration of the youth, the role of women in agriculture, and management of natural resources in the context of increasingly more severe climate change events. The ADS will ensure that the process of agricultural transformation is accelerated and molded according to the aspirations and constraints of Nepali society.

23 The lessons learned from the APP experience have been incorporated in the formulation of the ADS. Among these lessons are the need of ensuring governance, promoting effective participation of stakeholders, addressing land issues, effective support to decentralized research and extension, and promoting commercialization and competitiveness.

24 The ADS will accelerate agricultural sector growth through four strategic components related to governance, productivity, profitable commercialization, and competitiveness while promoting inclusiveness (both social and geographic), sustainability (both natural resources and economic), development of private sector and cooperative sector, and connectivity to market infrastructure (e.g. agricultural roads, collection centers, packing houses, market centers), information infrastructure and ICT, and power infrastructure (e.g. rural electrification, renewable and alternative energy sources). The acceleration of inclusive, sustainable, multi-sector, and connectivity-based growth is expected to result in increased food and nutrition security, poverty reduction, agricultural trade competitiveness, higher and more equitable income of rural households, and strengthened farmers' rights.

2.1.4 Water Resources Strategy

25 Water Resources strategy (WRS) 2002 has assessed the water resources potential of the country and has admitted integrated water resources development through river basin planning and management giving priority to irrigation development as one of the major water user. WRS recognizes the importance of irrigation to a sector that consumes water for agriculture, thus making it essential for addressing food security and poverty alleviation. Addressing on the existing issues of irrigation development WRS clearly focuses on short term, medium term and long-term strategy for the development and management of irrigation sector. The short-term goal of WRS stipulates the need of enhancing livelihood, food security and building sustainable partnership between related agencies including WUA, and during medium term period reliable irrigation service and efficient planning of new irrigation schemes will be enhanced. In the long-term, activities will focus on ensuring efficient, reliable and sustainable irrigation available to all irrigated areas. In concrete terms, the long-term vision of the irrigation sector is to provide irrigation services to 90 percent of irrigable lands, to increase cropping intensity to exceed 250 percent, to increase irrigation system efficiency of large surface irrigation systems to 60 percent, to establish and strengthen Water Users Association (WUA) that are capable of managing irrigation systems up to 5,000 ha, and to provide year-round irrigation to two-thirds of irrigated areas.

2.1.5 National Water Plan

26 National Water Plan (NWP) 2005 has also stressed the enhancement of irrigation development and sustainable management through various action programs. NWP proposes five action programs as integrated program for irrigated agriculture, improved management of existing irrigation systems, improved planning and implementation of new irrigation systems, strengthening and capacity building of local level institution in planning and project implementation and national capacity building of farmers.

2.1.6 Periodic Plans

27 Planned development in Nepal started in 1956. The nation has seen the implementation of nine five-year plans and three three-year plans. The present Thirteenth Plan (2013/14-2015/16) will expire in July 2016. The objectives, goals, strategy, and priorities of this Plan are all oriented towards securing this upgrade in status as well as to attaining the millennium and SAARC development goals; promoting sustainable development, human rights and adaptation to climate change; alleviating poverty by promoting a green economy; and addressing regional and international commitments. It is aimed at supporting the development of the agricultural sector through the multipurpose and sustainable development of the irrigation sector by the proper use of the water resources available in the country. It is projected that by the end of the Plan, the current irrigated area of 13, 11,000 hectares will be increased to 14, 87,275 hectares. However, the present pace of irrigation development does not support the targets of Thirteenth Plan.

28 Thirteenth Plan focuses on the implementation of small and medium surface and groundwater irrigation projects which can provide immediate returns and generate employment opportunities. It also focuses on providing year-round irrigation facilities through multipurpose reservoir and irrigation programs run under inter-watershed, water transfer, and water resource projects.

29 The problems which persist in this sector include deficiencies in resources, regular repair and maintenance of infrastructures, management of irrigation charges, and reinforcement of institutional capacity.

2.1.7 Irrigation Policy

30 The objectives of the Irrigation Policy, 2070 are- to develop and extend irrigation facilities sustainably for increasing agricultural productivity by maximum utilization of water resources of the country, to provide round the year reliable irrigation facility to the irrigation suitable land by proper maintenance and modernization of existing irrigation structures, effective water management and constructing new irrigation projects, utilization of the surface and ground water conjunctively for irrigation development, develop institutional capability and man power capacity for implementing multipurpose reservoir and inter basin transfer project and development of irrigation technology. The Policy also focuses on development of institutional capability of Water Users for sustainable management of irrigation systems. It also emphasized on enhancement of local knowledge and skill of governmental as well as non-governmental organizations involved in irrigation sector. The Policy explicitly focuses on the involvement of private sector in irrigation development and management, developing small-scale irrigation schemes by WUA and local government units, removing procedural bottle necks in the process of participatory approach in irrigation development, providing more focus on the use of non-conventional irrigation technology to cover marginal lands.

2.1.8 Rebate in tariff of electricity for Irrigation

31 The government has supported the farmers to promote irrigation facility through the rebate in electricity power consumed for irrigation. Present tariff rate is NRs 4.10 per kWh for 11kV and NRs 3.60 per kWh for 230-400 Volt irrigation users.

2.2 Lift Irrigation Systems in Nepal

32 Narayani, Marchwar, Battar, Western Koshi Pump Canal are the major lift Irrigation systems developed in the country. Under Medium Irrigation Project and New Irrigation Technology Project, many small to medium lift irrigation systems are now in operation. Department of Local Infrastructure Development and Agricultural Roads (DOLIDAR) is also constructing some small lift irrigation systems in Pyuthan, Kapilvastu, Dang and Kailali districts. Some of these lift systems are described in brief below.

2.2.1 Narayani Lift Irrigation System, Chitwan

33 Narayani Lift Irrigation System (NLIS) provides irrigation to the upper terraces of Narayani River in the vicinity of Bharatpur municipality. The project was commissioned in 1982 and was operational since in the name of Narayani Lift Irrigation System (NLIS). It was financed by the Asian Development Bank (ADB). The area directly under this system was 4,700 ha but now it is reduced to about 3200 ha. The NLIS has two staged pump and two canal systems: Canal-B and Canal-C. The pump -A lifts water from the river to 20 m high link canal and has the capacity to pump up to 17 m3/s while Pump-B lifts water from the link canal to Canal-C (18 m lift) It has the capacity to pump up to 7.2 m3/s. In pump house A, there are altogether 5 numbers of pumps- two -1200 KW pumps, two-750 KW pumps and one-330 KW pump. Similarly, there are altogether 4 number of pumps in Pump House B- one-500 KW pump, three-250 KW pump.

34 The system was broken down from 1992 to 1994, rehabilitation works were carried out for the pumps in “A” and resumed operation since then. The system is operating with difficulty as frequent break down of the electrical and mechanical parts occur. In addition, there are various deficiencies in the electro mechanical equipment. Sediment influx into the canals system is also a big problem. As per the demand of the farmers, the system is operational in June to September only for the paddy crops when the sediment content in the river water is high. The pumps are unable to operate during low flow in the winter and spring season. Suspended sediment concentration in the river varies largely due to geological phenomenon occurring in its catchment; it varies from 8000 – 15000 mg/l in general and might go up to 30000 mg/l during high flood.

35 There is problem of seepage in main canal B. Only 2 km length of Main canal- B is lined and the rest is earthen canal where seepage occurs largely.

36 Farmers think that the system was expensive, temporary, and irregular and having inadequate water supply. The main issues and concerns of this system are given below:

- Frequent damage of electro mechanical components.
- The electromechanical components are too old.
- The accessories are not easily available in the local market.

- Sediment Concentration High:

37 NLIS usually pump water during monsoon season when there is high sediment content in the river; whereas during winter and spring season low water level of the Narayani river gives trouble to run the pumps due to extreme vibration of the pumps. Sediment creates problems in the canal system, inlet channel, and it also damages the pump parts frequently. Suspended sediment concentration in the river varies from 8000 – 15000 mg/l in common and might go up to 30000 mg/l during high flood.

a. Urbanization and Reduction of Irrigation Area:

38 The existing irrigation system is located nearby Bharatpur municipality and other adjoining VDCs where there is regular influx of migrated population. Physical infrastructures like buildings, roads, etc. are extending in the command area. This has reduced the irrigation command area from 4700 hectares to around 3200 hectares.

b. Water Leakage from canals:

39 The NLIS is suffering from high leakage of the irrigation water from the main canal. Only two km length of canal B system from the beginning (especially urban area) is masonry lining and some for few other sections partly to prevent the seepage losses. About 3.5 km length of main canal C is lined and the branch canal CL-1 is lined within the urban area. The loss due to seepage in earthen channels is much more than loss by evaporation.

c. Agriculture Practice not as planned:

40 Farmers are mainly interested in cultivating paddy as monsoon crop. They are not motivated for crop diversification as initially planned. The cost of pumped water is high. The farmers should have chosen for cash crops. But here farmers prefer monsoon paddy.

d. High operating Cost:

41 To run the pumps, there is high tariff for electricity. Farmers are unable to understand the value of irrigation water. They are not realizing the cost that is incurred to pump this water. Until they feel the high cost of pumping, they shall not be motivated to go for crop diversification which is only the solution to accrue benefit from this project. High value cash crop and intermittent irrigation practice on demand basis with contribution to the cost of running of the pump is only the solution to sustain this irrigation system.

e. Unreliability of water Supply:

42 Farmers need reliable water supply for different crops. They are not convinced to get reliable water supply from the system. One of the main constraints is the reliability of water supply which needs a good and well maintained lift irrigation system.

2.2.2 Marchwar Lift Irrigation System (MLIS), Rupandehi

43 The project was implemented in three phases: first phase from 1981 to 1989, second phase from 1992 to 1996 and third phase from 1997 to 2000. The source of water for Marchwar Lift

Irrigation System (MLIS) is the Tinau River from where water is lifted using 6 Low Lift Pump (LLP) and 4 High Lift Pumps (HLP), keeping one LLP and one HLP standby. 5 LLPs, each with a discharge capacity of 765 lps, feed the Lower Main Canal (LMC) at static head of 4.9 meters (m). 4 HLP, each with a discharge capacity of 575 lps feeds the Upper Main Canal (UMC) at static head of 6 meters (m). The MLIP has constructed a pump house with ten pumps lifting water in the canals and a rural electrification program on the project area. The command area irrigated at present is 3500 hectares. Water availability depends on the water level and corresponding discharge in the river. Divisional Irrigation Office Rupandehi (DIO) and Water User Association (WUA) jointly operate and maintain pumps and canal system. With lack of funds and proper maintenance facilities, the standard practice of maintenance management could not be followed as a result a large number of pumps started to shut down and are in a stage of major repair.

44 High water demand during December and January forces pumps to operate below minimum required river level of 90 m. Operation of pumps against the standard operation practices results in unwarranted break down of pumps. This has been seen that a large number of pumps breakdown occurred due to operation of pumps during lean period. The frequency of breakdown of pumps when operated in lean period is high compared to pump when operated above minimum requirement level of 90 m. Thus the pumps if operated following operation guidelines of the manufacturer, the pumps can be operated for a longer duration resulting in drastic reduction in pump breakdown which in turn increase reliability of the pumping system and lowering maintenance cost.

45 WUA is independently taking care of O&M of the canal system. Irrigation Service Charge is the major factor to drive the system towards what we call sustainability. For sustainable operation arid maintenance of the pumps, Irrigation Service Charge should have collected in such a way that electricity tariff as well as operation and maintenance of the system could be realized easily form the revenue.

46 Frequent breakdown of machines, leakage and seepage through the earthen canal banks, roots of the trees spreading into banks and facilitating the leakage and seepage through banks, lack of technical backstopping support to WUA for maintaining the system, lack of trained manpower in local level, are some of the issues related to sustainability of the system.

2.2.3 Battar Lift Irrigation System, Nuwakot

47 This system was built in early 1980s to irrigate about 700 hectares of land in Battar and Pipaltar areas of Nuwakot district with water pumped from Trishuli River. It stood as a symbol of pride and prosperity of Battar until it ceased operating in the mid- 1990s. Then the largest project in Nuwakot District, it was expected to transform the socio-economic status of Battar residents. The system proved unsustainable mainly as a result of its high operation and maintenance costs. The key reason behind the failure of this system was its huge operation costs as the monthly electricity bill alone exceeded NRs 700,000, and farmers declined to pay a ‘fair share’ of the bill. Farmers still termed this brief period as a ‘golden time’ when the parched land produced a variety of vegetables and crops round the year before it turned back to the current state of aridity. Once a symbol of pride, Battar residents remember then running system which made significant contributions towards enhancing

agricultural productivity with a promising prospect of raising living standards for Battar farmers.

2.2.4 Western Koshi Pump Canal, Saptari

48 Western Koshi pump canal is designed to lift 11.3 m3/s of water from the Koshi West Main canal with a combined pump head of about 16 m in two stages to irrigate 13180 hectares of land.

49 Pump Station A

- At 1.37 km of pump main Canal.
- Installed Capacity of pumps: 14 m3/s
- Pumps: 6 numbers of vertical mixed flow pumps
  4 numbers of 2.75 m3/s capacity
  2 numbers of 1.5 m3/s capacity
- Static lift of the pump 6.7 m

50 Pump Station B

- At 4.64 Km of pump main canal
- Pumps: 6 numbers of vertical mixed flow pumps
  4 numbers of 2.75 m3/s capacity
  2 numbers of 1.5 m3/s capacity
- Static lift of the pump 8.473 m

2.2.5 Kiran Nala Irrigation System, Banke:

51 Kiran Nala Lift Irrigation System (KNLIS) was constructed by Department of Irrigation (DOI), District Division Office, Banke under Irrigation Line of Credit (ILC) program. The construction of this system was started in 1994 and was completed in 1996. Kiran Nala is the source of water. Five water pumps (three 15 HP and two 7.5 HP) with total capacity of 150 lps were installed. Main canal of length 1400m was brick lined. Initially this project was planned and developed for 165 hectares, later on farmers extended to irrigate 205 hectares utilizing different financial resources.

52 Breakdown of motor, electricity supply at low voltage, thefts of transformer are the main problems faced by the farmers. Farmers have very good system of collecting the money based on the supply of water. They also have penalties for delay in payment and a system of non-supply of water to defaulters. The team also noted that the farmers are very much active and have good knowledge and experience of lift irrigation.

53 It is seen that active role of WUA and beneficiaries is pre-requisite for sustainably running lift irrigation schemes.

2.2.6 Dhaulagiri Lift Irrigation System, Banke:

54 This subproject is constructed by District Division Office, Banke, Department of Irrigation under Medium Irrigation Project to irrigate 200 hectares of land at the cost of NRs.2, 99, 17,000 in Bageshwari VDC of Banke district. The water source is Kiran Nala. Design discharge of the canal is 0.25 m3/s. Intake structure consists of side intake and pump house with permanent cross weir. Two numbers of 35 HP and one number of 15 HP centrifugal pumps (Crompton) are used to pump 250 lps of water. Two suction pipes (GI) 0f diameter 8'' and one suction pipes (GI) 0f diameter 6'' are used to deliver water from the sump well. The total working head is 10.1m, suction head 6m and delivery head 4.1m. Main canal of length 0.950Km is RCC lined and is of rectangular section. Seven numbers of branch and tertiary canals altogether 4.155 Km length are also constructed.

55 Electricity supply at the required voltage of 400 volts is the main problem. Also there is problem of paying the electricity bills.

2.2.7 Farmer managed Lamachaur lift scheme- Pyuthan:

56 Lamachaur Lift Irrigation Scheme in Nayagaun VDC, Pyuthan is irrigating about 8.5 hectares of land. The water source of this scheme is Madi Nadi. This scheme was constructed with financial and technical support from Jhimruk Electricity Project about 10 years ago. The farmers are using 15 HP centrifugal pumps with suction head of 3m and delivery head of 65 m. The discharge is 5 liters per second. There is no sump well. The suction pipe is directly laid on the water pool. They take away the suction pipe out of the river during floods. The system is running successfully. They are now charging Rs 65 per hour watering. After seeing this system running successfully the farmers in nearby localities are making their minds to have their lift irrigation system same as this one.

2.2.8 Lessons Learnt from Running Lift Irrigation schemes

57 Some lessons learnt from these systems be considered while taking up the new lift irrigation schemes. Some of the lessons learnt are given below.

- Farmers' activeness is prerequisite for sustainably running the lift schemes.
- Strict rules regarding operation and maintenance are necessary. These rules must be followed by every beneficiary.
- At least 12 hours' electricity supply in a day is to be maintained.
- Pumps do not operate on low supply voltage. Therefore, one separate transformer is needed for the power supply of the pumping system.
- In some areas, there is problem of transformers being stolen. While installing the transformer, prevention against theft must be considered.
- At low voltage, the pumps should never be switched on. At low voltages, motor will burn.
- Training to farmers regarding maintenance of pumps, motors, electric panel board etc. is necessary.

- Water from lift schemes be economically used specially for high value crops. Traditional cereal crops like rice, wheat, maize will not give good returns to the farmers as the electricity tariff is high.
- After completion of the scheme, beneficiary community has to operate, maintain and manage the system. Therefore, their view must also be taken into account during implementation of the project.
- It is seen in most of the schemes that only one or two persons always are engaged right from survey and design stage of the scheme and they feel overburdened. Training must be given to the beneficiary community members so that they all play active role for the implementation, operation and maintenance of the scheme not some limited individuals only.

2.2.9 Irrigation in Kaligandaki, Marsyangdi, Daraundi Basins

58 Kaligandaki, Marsyangdi, Daraundi and Madi rivers originate from the high Himalaya of Western Nepal. The major tributaries of Kaligandaki are Rahughat Khola, Myagdi Khola, Badi Gad Khola, Ridi Khola, Modi Khola, Andhi Khola, Nisti Khola and Jyagdi Khola. Similarly, Chepe and Daraundi are the main tributaries of Marsyangdi River.These basins are well known for traditional irrigation culture. Several FMIS sustain the livelihood of the populace using the waters of tributaries. Argheli in Palpa, Shakhar in Syangja and Alsechaur in Gulmi are well documented by the researchers of irrigation management. Government has also developed many irrigation systems along the Kaligandaki basin. Argeli Irrigation System, Palpa Rampurphant Irrigation System, Palpa Chapakot Irrigation System, Syangja Andhikhola Multipurpose Project, Syagnja Sankhar Irrigation system, Syangja, Attrauli puttar Irrigation projct , Tanahun, Gadhi Jhauri irrigation project , Tanahun are the main irrigation systems in operation in Kaligandaki basin.

59 Similarly, Rainas tar, Handetar, Bhorletar, Ramgha tar are the irrigation systems in Lamjung district in Marsyangdi and Madi nadi Basins.

60 Kundur tar Irrigation Project is under construction in Daraundi Basin. It will be completed in near future.

61 Besides these, many small Farmer Managed Irrigation Systems are in operation in all these basins. Farmers themselves built and manage these systems from time immemorial.

62 Many terraces in these basins are still deprived from irrigation facilities. Farmers in big tars like Palungtar, Gaikhur tar, Chyanglitar in Gorkha district along Marsyangdi basin are depending on rain fed irrigation for the cultivation on their lands. Similarly, Bhalayatar, Aanpchaur-Parichaur-Belchaur and several tars along Kaligandaki basin in Palpa, Tanhun and Syangja districts are still dry tars. In Madi basin several tars along the river are dry in Lamjung and Tanahun districts.

2.3 Agencies Involved in Hill Lift Irrigation

2.3.1 Ministry of Irrigation

63 Ministry of Water Resources was divided into Ministry of Energy and Ministry of Irrigation (MoI) in 2009.The responsibility of utilization and management of water resources lies in the

Ministry of Irrigation. Preparation of plan and policies, their implementation regarding development of irrigation for the efforts to achieve agricultural development targets, are the objectives of this ministry. It is responsible for coordinating programs on irrigation development and management. It formulates the plans and policies with respect to participatory irrigation management and development of appropriate technology to suit the local needs of irrigation. Realizing the need of short and long-term strategy for irrigation development Ministry has recently promulgated Irrigation Policy-2070, which enlightens the need of integrated development of water resources in river basin concept. The Policy also emphasizes on the development of hill irrigation focusing on small landholders and marginal lands.

2.3.2 Department of Irrigation

64 Department of Irrigation (DOI) is the leading government agency responsible for the development and management of irrigation in the country. The DOI was established in 1952 and has recently completed its 63rd anniversary. Starting with four engineers the Department has now over 2000 staff in its several division and sub-division offices and five regional directorates. At its present form DOI has Fifty-seven divisions and sixteen sub-division offices covering all geographical regions to look after surface irrigation developments. There are thirteen management divisions for management of completed large irrigation systems. In addition, nine field offices are also existed to look after groundwater irrigation. The major objectives of DOI are preparation of plans and policies related to irrigation development and management, developing cost effective technology for irrigation, providing services to irrigated agriculture, feasibility study of potential projects and their successful implementation, and management of developed irrigation systems.

2.3.3 Department of Agriculture

65 Department of Agriculture (DOA) is the central institutions responsible for providing agriculture extension services and technology to farmers in the country. DOA and its regional and district offices are represented on irrigation development committees at various levels. However, the reported performance of agricultural extension is below expectations and its functional coordination with irrigation projects and programs is not encouraging.

2.3.4 Water and Energy Commission Secretariat

66 Water and Energy Commission Secretariat (WECS) is the nodal agency for formulating Water Resources Strategy and National Water Plan. WECS has accomplished several studies on performance impact and inventory of water use in the district basis and involved in survey and evaluation works. However, the functional linkage of WECS and irrigation development is weak and need to reformulate the organizational structure to suit the spirit of WRS and NWP.

2.3.5 Agricultural Development Bank

67 Agricultural Development Bank of Nepal (ADBN) is the semi-governmental financial institution responsible for providing support services to irrigated agriculture. It provides loan and technical support to farmers and water users for the development of Shallow tube well (STW) and small-scale irrigation systems. In addition to STW the role of ADBN in encouraging micro irrigation in the hills is also significant. The technical enhancement of water users, as well as follow-up programs during operation of irrigation schemes is vital for their effective use and sustainability. In this aspect the role of ADBN is crucial to increase the technical capability of farmers to introduce commercial agriculture and local governance.

2.4 Issues and concerns of hill irrigation

a. Low Irrigation Coverage

68 The total cultivable land of the country is 2.64 million ha of which only 1.76 million is possible for some kind of irrigation. The present status of irrigation infrastructure development is about 1.368 million ha. Despite the encouraging targets of periodic plans the present pace of irrigation development is not so encouraging. The irrigated area coverage in the hills is about half of its potential and several tars and phants are still having rain fed agriculture.

69 Realizing the need of poverty alleviation through the diversified development of irrigated agriculture the present pace of irrigation development seeks accelerated activities in increasing irrigation coverage. For this the remaining un-irrigated areas in river basins have to be irrigated. In this aspect this study aiming to explore the potentiality of lift irrigation development in Kaligandaki , Marsyangdi, Daraundi and Madi nadi terraces in Palpa, Syangja, Gorkha, Lamjung, Tanahun districts is of vital importance.

b. Less Area Covered by Year-round Irrigation

70 Most surface irrigation systems designed in the past provide supplementary irrigation to main paddy crops during monsoon and groundwater irrigation has focused on conjunctive use of rainfall. Though the infrastructures developed for providing irrigation facilities can support large areas, the year round irrigation coverage is less than expected. The main reasons are inadequate water resources in small and medium rivers with run-of-the river diversions without storage facility, Medium rivers like Kankai, Kamala, Bagmati, Babai and southern rivers originating from Chure hills have low flow in winter and spring and could not cope with irrigation water requirement of the irrigable land. Harnessing large river systems for multipurpose project, conducting lift irrigation schemes in large rivers and effective implementation of groundwater irrigation for conjunctive use are the main issues to be addressed for providing year round Irrigation.

c. Low Level of Water Use Efficiency

71 Many irrigation systems developed in the past have deteriorated physically and institutionally and do not perform as planned. Non-Systematic operation and improper maintenance are the drawbacks of these systems, which deliver less or no water to the tail

ends in proportion to the available water at the headwork. Some essences of Farmer Managed Irrigation System like equitable distribution of water through the enforcement of socially accepted rules and regulations have not been carefully addressed in planning, design, implementation and operation of agency managed irrigation systems. Especially in case of lift irrigation, systematic operation, proper maintenance, strict enforcement of socially accepted rules and regulations will enhance the water use efficiency.

d. Under Utilization of Developed Infrastructures

72 Irrigation development has not substantially enhanced the agricultural production and productivity. These are reflected in marginal increase in cropping intensity and crop yields. These are mainly due to improper intervention of appropriate technology, marketing and processing facility, diversification and commercialization of agricultural products. This is reflected in use of pumping hours by deep tube wells in Terai. Major deep tube wells do not run as per the designed running hours. In design of lift schemes in hills, this issue has to be properly addressed.

e. Need of Holistic Planning

73 In the past there was lack of holistic planning in irrigation projects. But in recent years, while designing an irrigation project, holistic approach of water resource development and management is being considered. Environmental concerns, geological considerations, hydrological considerations, analysis of sediment flow, possible locations of landslides, preparedness to cope with water induced disasters are the major concerns of irrigation that need holistic approach.

3.0 LIFT IRRIGATION SCHEMES AREA

3.1 Indicators / Criteria and process for selection of potential lift schemes

74 The team developed criteria and assigned marks against the various indicators such as availability of sizable irrigable land, possibility of pumping lift, proven deficiency of water faced by the farmers, limiting the opportunity of crop diversification and productivity enhancement, potential of improvement in cropping system and practices and gains in the productivity and income with the development of the scheme, willingness of the users to invest in the development of the scheme and pay the cost of subsequent operation and management, possibility of connectivity of national grid with no major investment involved in the development/extension of the transmission line to the site of the lift scheme. Three schemes having higher score will be selected for further study. Based on above work an inception report was prepared and submitted.

75 Some preliminary lift schemes have been identified on the basis of desk study considering the location, average command area and lifting head. Location and List of these preliminary candidate schemes is presented in Annex-2.

3.1.1 Field investigation

76 The main objectives of field work was to verify the data collected during the desk study, collect additional data, and also collect on-the-spot data and information relating to the pre-feasibility of the Kali Gandaki, Marsyangdi, Daraundi and Madi basins. Field level Studies were carried out by the team members. These studies, observations and investigations help to generate pre-feasibility stage design data and also supplement /validate the secondary data relevant to proposed development. Focus Group discussions (FGD), Key Informant Consultation (KIC) and walk-through at main points of the system were the principal tools applied during the course of field study. Formats and check list were prepared for information collection in Annex-3.

3.1.2 Visit of Local Offices and Data Collection

77 The team visited the local offices relating to the study in Gorkha, Lamjung, Tanahun, Syangja, Palpa districts. The local offices included Irrigation Division Offices (IDO), District Agriculture Development Offices (DADO). The team visited Regional Directorate Offices of Irrigation and Agriculture Development in Pokhara. This visit was aimed to verify all the data collected in the desk study stage together with collection of additional data from them. The study team mainly collected the data related to water resources potential, land resources potential, existing irrigation systems, agro-climatological data, agriculture practice, input uses and availability, and overall income level of farmers. The formats developed during inception stage were used in this regard.

3.1.3 Visit of Particular Location of the Basins and Walk Through

78 Site visits were undertaken by the team three times. Particular locations suitable for Lift irrigation in Daraundi Basin in Gorkha district were visited first. Similarly, the team visited Marsyangdi basin in Tanahun and Lamjung, Madi Basin in Lamjung and Tanahun and Kaligandaki Basin in Palpa, Syangja and Tanahun districts. The team visited the major agricultural and settlement area, and gathered information on the agricultural practices, availability of irrigation water, potential for irrigation development including lift irrigation, and farmer's attitude towards improved agricultural practices. The team also got information on the available market situation for Agri- inputs and agricultural productions. For lift schemes, the availability of 11kV electric connectivity or other power source was also studied. Discussions were held with farmers in numbers of locations to identify the existing constraints and possible solutions for irrigation development.

3.1.4 Primary Selection of lift schemes

79 Altogether 55 schemes were primarily studied by the team in Kaligandaki, Marsyangdi, Daraundi and Madi Basins.

80 Based on the developed criteria the team assigned score against the various indicators such as availability of sizable irrigable land under permanent cropping, Water availability at the source, major limitations emerging from topography, accessibility, marketing of input and output, possibility of pumping lift, deficiency of water faced by the farmers, potential of improvement in cropping system and practices, willingness of the users to invest in the development of the scheme and pay the cost of subsequent operation and management, possibility of connectivity of national grid /extension of the transmission line to the site of the lift scheme- availability of National grid/ local electricity supply line in medium voltage 11kV, irrigated Agriculture, WUA institution etc.

81 In order to develop a common understanding on the scores of the schemes, the field processes of assessment, assessment tools and plan of action, the team maintained close coordination/consultation with the project and DoI. DoI’s suggestion for the selection criteria was incorporated. Based on this selection Criteria (Annex 4), scores were given to systems of each River Basin. The Table no 1 below shows the summary of scores of the systems. Calculation of scores of the systems is given in Annex 4.1 to Annex 4.6.

Table 1: Summary of scores of the systems

Basin	Name of System	District	Command Area	Lifting Head	Total score
Kaligandaki	Majhigaun, Chhap, Bojha,Hungi - 5	Palpa	110.3	50	68.00
	Naugaun , Heklang	Palpa	10	51	65.50
	Ramtar, Shik danda , Rampur 15	Palpa	16.3	71	61
	Bhujat, Rampur 13	Palpa	16.5	45	68

Basin	Name of System	District	Command Area	Lifting Head	Total score
	Ekletar, Aanpchaur	Palpa	91.6	45	68
	Tilakpur, Rampur 9	Palpa	229	55	65.5
	Dedgaun	Nawalparasi	79.7	60	58
	Bakram	Nawalparasi	38.5	40	65.5
	Debra	Nawalparasi	118	65	55.5
	Hattisar	Nawalparasi	14.4	37	65.5
	Dhudeni	Nawalparasi	23.2	33	64.25
	Gaidakot	Nawalparasi	32.5	37	65.5
	Kishangaun	Syangja	31.3	35	66.75
	Bankatta	Syangja	20.4	40	66.75
	Puttar	Tanahun	213	93	54
	Devghat	Tanahun	601	78	68.75
	Bhalayatar 1, Rampur 3	Palpa	15.3	56	69.5
	Bhalayatar 2, Rampur 3	Palpa	50.5	65/51	69.5
	Bhalayatar 3, Rampur 3	Palpa	46.5	54	69.5
	Aanpchaur	Syangja	179.9	197	55
	Shekham,sakhar	Syangja	178	71	53.5
	kota	Tanahun	152	123	51.75
	Pipaltar,Ruptar,Madhuwantar 1	Tanahun	114	133	49
	Pipaltar,Ruptar,Madhuwantar 2	Tanahun	351	142	49
	Gadyoulitar/Bantar/Jagaulitar	Tanahun	374	103	49
	Simaltar	Tanahun	200	220	43.00
Marsyangdi	Chyangli lowland	Gorkha	420	55	69.50
	Chyangli Highland	Gorkha	180	112	62.50
	Simle-Bhansar	Tanahun	118	39	64
	Abukhaireni	Tanahun	147	70	56.50
	Markichok	Tanahun	49.4	53	59.00
	Satrasayaphat 1	Tanahun	118	58	59.00

Basin	Name of System	District	Command Area	Lifting Head	Total score
	Satrasayaphat 2	Tanahun	35.6	65	56.50
	Chambas	Tanahun	12.8	34	65.25
	Turture	Tanahun	11.7	32	59.25
	Purkot	Tanahun	402	66	56.50
	Simlephat	Gorkha	91.4	49	59
	Devighat	Gorkha	33.9	32	64.00
	Rainashtar Garam besi	lamajung	46.5	44	56.5
	Palungtar	Gorkha	638	125/116	58.25
	Gaikhur-kalamata	Gorkha	54	40	64.00
	Gaikhur, Santar	Gorkha	7.74	140	49.50
	Gaikhur,Jaisithok	Gorkha	8.16	140	49.50
	Gaikhur Dandathok	Gorkha	20	73	52.00
	Khatritar, Gaikhur	Gorkha	177	125	49.50
	Bhanu	Tanahun	520	178	58.25
Daraundi	Chorkate Tar	Gorkha	83.6	150	57.50
	Kundur Tar	Gorkha	159	68	57.00
	Chhepe Tar	Gorkha	106	90	54.00
Madinadi	Dui piple (Sisa ghat)	Lamjung	264.7	48	70.5
	Satra saya phant (Sankhuli), Kyamin 7	Tanahun	46.3	67	65.5
	Pathra Besi, Dulepani Kyamin 7	Tanahun	32	23	78
	Kalesti bote gaun, Kyamin 1	Tanahun	34.2	54	68
	Kalesti phant , Kyamin 1	Tanahun	62.4	52	68
	Baireni (Kumaltari),Byas 5	Tanahun	81.4	40	75.5

3.2 Three clusters for further assessment

82 On the second visit, the team used GPS machine to locate the command area and assess the available head for lift irrigation.

83 After assigning ranks, the 55 schemes are grouped in cluster. For grouping in clusters, command area, distance between two schemes, farthest distance between the two schemes and score of individual schemes are taken into consideration. The maximum distance between two adjacent schemes shall not be more than 7 km within a cluster. Cluster selection calculation, cluster ranking and selection of three clusters are given in Annexes 5, 6 and 7. Clusters are ranked as given below in Table 2.

Table 2: Three Clusters for further Study

Cluster Name	Basin	Name of the System	District	Command area	Lifting Head	Total score	Overall Score of the cluster after correction for area	Rank of the cluster
Madinadi 1	Madinadi	Pathra Besi, Dulepani Kyamin 7	Tanahun	32	23	78	72.17	1
	Madinadi	Baireni (Kumaltari),Byas 5	Tanahun	81.4	40	75.5		
	Madinadi	Dui piple -Sisa ghat	Lamjung	264.7	48	70.5		
	Madinadi	Kalesti Botegaun, Kyamin 1	Tanahun	34.2	54	68		
	Madinadi	Kalesti phant, Kyamin 1	Tanahun	62.4	52	68		
	Madinadi	Satra saya phant (Sankhuli), Kyamin 7	Tanahun	46.3	67	65.5		
Marsyangdi 1	Marsyangdi	Chyangli lowland	Gorkha	420	55	69.50	70	2
	Marsyangdi	Chyangli Highland	Gorkha	180	112	62.50		
Kaligandaki 1	Kaligandaki	Bhalayatar 1	Palpa	15.3	56	69.50	69.99	3
	Kaligandaki	Bhalayatar 2	Palpa	50.5	54	69.50		
	Kaligandaki	Bhalayatar 3	Palpa	46.5	54	69.50		
	Kaligandaki	Majhigaun, Chhap, Bojha,Hungi - 5	Palpa	110.3	50	68		
	Kaligandaki	Bhujat, Rampur 13	Palpa	16.5	45	68		
	Kaligandaki	Ekletar, Aanpchaur	Palpa	91.6	45	68.00		
	Kaligandaki	Naugaun , Heklang	Palpa	10	51	65.50		
	Kaligandaki	Tilakpur, Rampur 9	Palpa	229	55	65.50		
	Kaligandaki	Ramtar, Shik danda , Rampur 15	Palpa	16.3	71	61.00		
Kaligandaki 2	Kaligandaki	Kishangaun	Syangja	31.3	35	66.75	58.20	6
	Kaligandaki	Bankatta	Syangja	20.4	40	66.75		
	Kaligandaki	Aanpchaur	Syangja	179.9	197	55.00		
	Kaligandaki	Shekham,sakhar	Syangja	178	71	53.50		
Kaligandaki 3	Kaligandaki	Bakram	Nawalparasi	38.5	40	65.50	57.19	8
	Kaligandaki	Hattisar	Nawalparasi	14.4	37	65.50		

Cluster Name	Basin	Name of the System	District	Command area	Lifting Head	Total score	Overall Score of the cluster after correction for area	Rank of the cluster
	Kaligandaki	Gaidakot	Nawalparasi	32.5	37	65.50		
	Kaligandaki	Dhudeni	Nawalparasi	23.2	33	64.25		
	Kaligandaki	Dedgaun	Nawalparasi	79.7	60	58.00		
	Kaligandaki	Debra	Nawalparasi	118	65	55.50		
Marsyangdi 2			Tanahun	12.8	34	65.25	**61.28**	**4**
	Marsyangdi	Simle-Bhansar	Tanahun	118	39	64		
	Marsyangdi	Turture	Tanahun	11.7	32	59.25		
	Marsyangdi	Markichok	Tanahun	49.4	53	59.00		
	Marsyangdi	Satrasayaphat 1	Tanahun	118	58	59.00		
	Marsyangdi	Bhanu	Tanahun	520	178	58.25		
	Marsyangdi	Abukhaireni	Tanahun	147	70	56.5		
	Marsyangdi	Satrasayaphat 2	Tanahun	35.6	65	56.5		
Marsyangdi 3	Marsyangdi	Palungtar	Gorkha	638	125/116	58.25	**58.47**	**5**
	Marsyangdi	Gaikhur-kalamata	Gorkha	54	40	64		
	Marsyangdi	Gaikhur Dandathok	Gorkha	20	73	52.00		
	Marsyangdi	Gaikhur, Santar	Gorkha	7.74	140	49.50		
	Marsyangdi	Gaikhur, Jaisithok	Gorkha	8.16	140	49.50		
	Marsyangdi	Khatritar, Gaikhur	Gorkha	177	125	49.50		
Marsyangdi 4	Marsyangdi	Rainashtar Garam besi	lamajung	46.5	44	57.75	**57**	**9**
	Marsyangdi	Purkot	Tanahun	402	66	56.5		
Daraundi	Marsyangdi	Simlephat	Gorkha	91.4	49	59	**57.67**	**7**
	Darundi	Kundur Tar	Gorkha	159	68	58.25		
	Daraundi	Chorkate Tar	Gorkha	83.6	150	57.5		
	Kaligandaki	Chhepe Tar	Gorkha	106	90	55.25		
	Marsyangdi	Devighat	Gorkha	33.9	32	64		
Kaligandaki 5	Kaligandaki	Pipaltar,Ruptar,Madhuwantar 1	Tanahun	114	133	49.00	**51.53**	**10**
	Kaligandaki	Pipaltar,Ruptar,Madhuwantar 2	Tanahun	351	142	49.00		

Cluster Name	Basin	Name of the System	District	Comma nd area	Lifting Head	Total score	Overall Score of the cluster after correction for area	Rank of the clust er
	Kaliganda ki	Gadyoulitar/Bantar/Jaga ulitar	Tanahun	374	103	49.00		
	Kaliganda ki	Kota	Tanahun	152	123	51.75		
Kaligandaki 6	Kaliganda ki	Simaltar	Tanahun	200	220	43	**42.5**	**11**
	Kaliganda ki	Devghat	Tanahun	601	78	68.75	Rapidly urbanizing	
	Kaliganda ki	Puttar	Tanahun	213	93	54.00	Existing surface irrigation	

Source: Field Survey and discussion-2016

84 Based on the cluster ranks, the three clusters for further study are- Madi 1, Marsyangdi 1 and, Kaligandaki 1. Their average gross command area is about 569 hectares. In these selected three clusters there are 17 individual systems. From now on, this Report is considering these three clusters altogether as a project. Its name is given as Mid Hill Lift Irrigation Project.

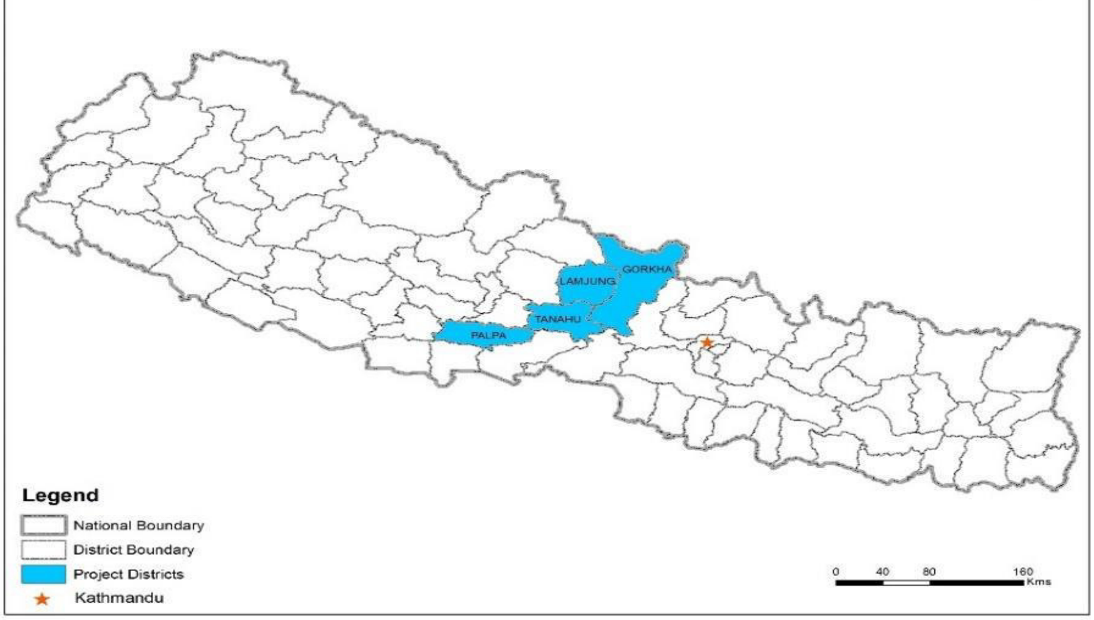
3.3 Location and accessibility of Three Clusters

85 The proposed project area is located in the three basins- Madinadi, Kaligandaki, Marsyangdi basins. Project area in Madinadi 1 cluster, is along Madinadi River in Byas Municipality and Kyamin VDC in Tanahun and Duipiple sisaghat in Madhya Nepal Municipality in Lamjung district. Marsyangdi 1 cluster is located along the left bank of Marsyangdi River in Palungtar Municiplaity in Gorkha district. The third cluster, Kaligandaki 1, is along the Kaligandaki basin in Rampur Phant Municipality, Hungi VDC and Heklang VDC.The area of this cluster is stretched from Bhalaya tar to Heklang along Kaligandaki corridor road.

86 According to the geographical co-ordinates the project area for Madinadi 1 cluster lies between 27o59' N to 28o 06’ N latitudes and 84o 14’ E to 84o 15' E longitudes, project area for Marsyangdi 1 cluster lies between 27o57' N to 27o 59’ N latitudes and 84o 25’ E to 84o 26' E longitudes and project area for Kaligandaki 1 cluster lies between 27o51' N to 27o 54’ N latitudes and 83o 43’ E to 83o 57' E longitudes. The project area has been shown in location map (Figure 1). The area for Madi 1 cluster is accessible with motor able road from Damauli and it is within 20 km distance from Tanahun district head quarter Damauli. From Kathmandu this project area is about 140 km on western direction. The nearest airstrip from the project area is Pokhara, from where daily flight links with Kathmandu are available.

87 The area for Marsyangdi 1 cluster is accessible with motor able road from Nayapul in Prithvi Highway about 125 Km from Kathmandu. It is within 10 km distance from Nayapul. The nearest airstrip from the project area is Pokhara. The area for Kaligandaki 1 cluster is accessible with motorable road from Arya Bhanjyang and has about 60 km from district head quarter Tansen and about 25 Km from Pipaladanda in Siddartha Highway (near Ramdi Bridge). From Kathmandu the project area is about 300 Km on south-western direction. The project area is also accessible from Bhimad in Tanhun via Keladi Ghat Bridge in Kaligandaki River (4 hours’ drive). The nearest airstrip from the project area is Bhairahawa. Daily flight links are available to Kathmandu.

Figure 1 Cluster located Districts



3.4 Climate of cluster area

88 The climate of study area is tropical monsoon climate with two distinct seasons, the wet season and dry season. The wet season starts from June and ends on September while dry season continues from October to May. The rainfall occurs mainly during wet season, which is caused by orographic effect of Himalayan topography. The average annual rainfall of study area ranges from 2,000 mm to 2,600 m. The hottest months are May and June while coldest months are December and January. The average maximum temperature is 29°C while minimum is 17°C. The monthly average maximum and minimum temperatures and rainfall of some locations are presented in tabular form (Table 3).

Table 3 Mean monthly rainfall and temperature of the project area

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Station: Damauli, Tanahun (Station no 817)													
Rainfall mm	16	10	27	65	182	438	649	572	325	100	5	5	2394
Temp Maxim °C	21.6	24.9	30.3	34.5	34.4	33.3	31.6	31.5	31	30.1	26.3	22.3	
Temp Mini °C	7.94	9.18	13.4	17.8	20.1	21.9	22.4	22..2	21.1	17.9	11.7	8.3	
Station Bhalaya Tar													
Rainfall mm	21	10	28	50	146	363	571	465	258	98	2	6	2018
Temp Maxim °C	21.4	24.5	29.7	34.2	34.2	33.2	31.3	31.1	30.7	29.7	26.2	22.3	
Temp Mini °C	9	10.3	14.6	19.4	22	23.7	23.9	23.6	22.5	19.6	13.3	9.3	
Station Bimalnagar													
Rainfall mm	18	16	30	69	178	439	638	593	334	95	8	7	2425
Temp Maxim °C	21.6	24.6	30.1	34.3	34.5	33.1	31.5	31.4	30.9	30	26.3	22.3	
Temp Mini °C	9.6	10.6	15.1	19.4	21.9	23.1	23.9	23.6	22.6	19.6	13.8	9.7	
Bhorletar													
Rainfall mm	16	12	36	83	237	502	706	626	349	109	6	5	2627
Temp Maxim °C	20.9	24	29.3	33.1	33.0	32.3	30.9	30.7	30.3	29.2	25.5	21.5	
Temp Mini °C	9.1	10.2	14.7	18.7	20.8	22.7	23.1	22.8	21.9	18.6	13.1	9.2	

Source: http://en.climate-data.org/country/26/

3.5 Topography, Soils and land use of cluster area

89 Topography: The topography of the study area is the river valley terraces of Madinadi, Marsyangdi and Kaligandaki River intersected by small rivers and streams. These are small to large phants with hill terraces and undulations. The area is highly populated and farmers have access to electricity, modern communications.

90 Transportation facility in Madi 1 cluster area is good. Here project area is connected by all-weather road. Clusters Marsyangdi 1 and Kaligandaki 1 are connected by fair weather road. There is one earthen road from Hungi to Bhalayatar via Rampur Phant in Palpa. This road is under Kaligandaki corridor. All the study area is located at the range of 23 - 197 m above the river bed level. Thus, lifting water from rivers is possible.

91 Soils: The soil Type of the proposed all clusters are all most the same i.e., Loamy and with yellowish color in the partially irrigated area. Where as in the case of upland i.e. bari loamy with red color. The soil texture is observed suitable for the crops like maize, paddy, wheat, potato, legume crops with different vegetables.

92 Land Use: Farmers have cultivated almost all of the potential land area but irrigation facility is lacking in most parts. The land use of the area is based on the topography and availability of water for irrigation. In some areas, the low land has some sort of irrigation for one crop during rainy season to some extent while highland is not irrigated. The total area under consideration in all three clusters is estimated as 1707 ha, of which about net cultivated land is 1366 ha .Out of this cultivated land, 1063 hectare is rain fed and 303 hectare is partially irrigated. (Table 4)

Table 4 Land Resources Potential of Study Area

Name of Cluster	Name of the System	Name of VDC/Municipality	Gross Command Area	Cultivated land ha	Rain fed land ha	Partially Irrigated land ha
Madi-1	Pathra Besi, Dulepani, Kyamin 7	Kyamin	32	25.6	9.6	16
	Baireni (Kumaltari),Byas 5	Byas Municipality	81.4	65.12	59.1	6.02
	Dui piple, Shisa ghat	Madhya Nepal Municipality	264.4	211.52	165.52	46
	Kalesti Botegaun, Kyamin 1	Byas Municipality	34.2	27.36	15.36	12
	Kalesti phant, Kyamin 1	Byas Municipality	62.4	49.92	24.92	25
	Satrasaya phant (Saankhuli), Kyamin 7	Kyamin VDc	46.3	37.04	22.04	15
Marsyangdi -1	Chyangli lowland	Palungtar Municipality	420	336	200	136
	Chyangli Highland	Palungtar Municipality	180	144	144	0
Kaligandaki -1	Bhalayatar 1	Rampur Municipality	15.3	12.24	12.24	0
	Bhalayatar 2	Rampur Municipality	50.5	40.4	40.4	0
	Bhalayatar 3	Rampur Municipality	46.5	37.2	30.2	7
	Majhigaun, Chhap, Bojha, Hungi 5	Hungi VDc	110.3	88.24	63.24	25
	Bhujat, Rampur 13	Rampur Municipality	16.5	13.2	9	4.2

Name of Cluster	Name of the System	Name of VDC/Municipality	Gross Command Area	Cultivated land ha	Rain fed land ha	Partially Irrigated land ha
	Ekletar, Aanpchaur, Rampur 11	Rampur Municipality	91.6	73.28	68.5	4.78
	Naugaun, Heklang	Heklang VDC	10	8	6.5	1.5
	Tilakpur, Rampur 9	Rampur Municipality	229	183.2	183.2	0
	Ramtar, Shikdanda, Rampur 15	Rampur Municipality	16.3	13.04	9	4.04
	Total		1707	1366	1063	303

Source: Field Survey, 2016

93 From the table it is seen that the most of the land is rain fed and is in need of irrigation. The productivity is low due to lack of irrigation.

94 The Madi 1 area in Madi nadi Basin is having comparatively low lifting head. The river terraces in this cluster are mostly having one crop.

95 The Marsyangdi 1 area in Marsyangdi Basin is having two tiers of land- one at the lower level and the other one in higher level. In the years having sufficient rainfall, the farmers in lower terraces go for rice cultivation. In the years of scant rainfall, they go for other crops like maize. The high land farmers are based on rain fed agriculture.

96 The Kaligandaki -1 cluster area, Bhalayatar is almost rain fed. Tilakpur and other small patches of lands along Kaligandaki corridor are practicing crop rice in most of the areas.

4.0 HYDROLOGY AND WATER RESOURCE ASSESSMENT

4.1 General Hydrology

97 The general hydrology of the study area is influenced by the southeast monsoon during months of June to September. The monsoon air stream is forced to rise as it meets the Himalayas resulting in heavy rainfall on the slopes facing southwards. The study area is categorized as medium rainfall zone of Mahabharat hills. The winter rainfall is related to weather systems moving from the west. As the study area lies below 2,500 m altitude there is no snowfall. In addition, the study area is formed with several drains and small rivers draining to Kaligandaki, Marsyangdi, Daraundi, Madi. The topography and geology of the area tend to promote rapid runoff mainly during monsoon season and availability of water for irrigation is limited. Water from the big rivers is not utilized for irrigation. Water sources which could be tapped easily have already been committed for irrigation and new area for irrigation is planned to go for lift from the big rivers. The discharge data for Kaligandaki, Marsyangdi are taken from Kaligadaki and Marsyangdi hydropower Projects. Madinadi discharge is obtained from Department of hydrology data.

4.1.1 Available Water in Study area and Flow Assessment

98 The study area is mostly sloping terraces along the Kaligandaki, Marsyangdi and Madi rivers. The area is intersected by various small rivulets and drains, which are basically active only during monsoon season. For our clusters we use Kaligandaki, Marsyangdi, Madi River water. Water is sufficient in these rivers. For Bhalayatar in Palpa we use water from Nishti Khola. The discharges are tabulated as given in Table 5

Table 5 Assessment of Mean Monthly Flow

River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kaligandaki River Discharge at Mirmi Syangja, 2010												
Average Discharge Cumecs	61.59	55.31	56.22	69.39	81.85	201.11	939.97	1062.41	942.41	285.56	133.94	83.94
Marsyangdi River Discharge at bimal nagar, 2009												
Average Discharge Cumecs	54.9	63.7	75.7	60.7	92.2	165	590	653	427	269	113	70.1
Madi nadi River Discharge at Bimal nagar, 2010												
Average Discharge Cumecs	18.2	16.4	17.2	21.1	27.2	45	152	178	164	69.5	36.2	25.4
Nisti Khola, Palpa												
Average Discharge Cumecs	4.14	3.12	2.33	1.71	1.56	4.68	19.20	23.88	17.13	11.17	7.79	5.7

Source: for Nishti Khola, District Division Office , Palpa

4.1.2 Sediment Data

99 The project area is characterized by steep gradient with numerous rapids in upper reaches. The influence of heavy rain during the monsoon period causes wide variation in river flow, land erosions and landslides. Coupled with the fragile geological composition of the project area, this produces the high sediment loads in the rivers. Besides this, during summer, snow and glacier melt also bring heavy loads of sediment. There is no specific sediment data for the purpose of this project. However extensive sediment study of Kaligandaki river at Mirmi and of Middle Marsyangdi Hydroelectric Projects could be taken as reference for Project Study. The Sediment data for these rivers as available from Hydro power stations are given in Table 6.

Table 6 Sediment Data -Marsyangdi River, Madhya Marsyangdi Dam site

Year	Maximum Concentration (mg/l)	Maximum Concentration (ppm)
1991	10,620	10632
1992	11,900	11913
1993	9,470	9481
1994	10,059	10070
1995	12,942	12957

Table 7 Sediment Data - Kaligandaki River, Dam site, Mirmi

Year	Maximum Concentration (mg/l)	Maximum Concentration (ppm)
2006	7,880	7889
2007	7,739	7748
2008	7,430	7439
2009	8,670	8680
2010	6,389	6396

100 As we see from the table, the maximum sediment concentration for Marsyangdi River is 10059 mg/l and for Kaligandaki River it is 8670 mg/l. We could not get data for Madinadi. We can take Marsyangdi data as reference for Madinadi. For Narayani Lift system in Narayangadh, the suspended sediment concentration in the river is varying from 8000 – 15000 mg/l (maximum 30000 mg/l during high flood) and this is causing wear and tear of pump parts and siltation in canals and fields. Similar will be the case in lift systems in Kaligandaki, Marsyangdi and Madi basin, if due consideration is not given to sediment management.

101 In our case, we shall not use pumps during flood season when there will be high sediments loads. The cropping calendar and patterns are proposed accordingly.

4.2 Crop coefficients

102 As per the requirement of Terms of Reference, for conceptualization of design considerations and type and size of system components, the following three systems in each cluster is being taken as representative for each cluster.

- Madi 1
- Marsyangdi 1- Chyangli low land and High land, Gorkha
- Kaligandaki 1
- Crop coefficient, water requirement, cropping pattern etc. are calculated and analyzed for these four systems.

103 Crop coefficients for computing crop water requirements for the various existing and proposed crops in the study area have been adopted from FAO Crop Wat 8 software. Crop coefficients for major crops are shown in Table 8. Detail Calculation is given in Annex 8.

4.3 Water Requirement Calculation

104 The crop water requirements of various crops grown in the command area of the Project have been calculated on the basis of evapo-transpiration, crop coefficients, and effective rainfall of the area. Crop Wat 8 FAO software is used to calculate crop water requirements of various crops. The total crop water requirement for the proposed crops in different months of the year is presented in Annex 8. The proposed cropping pattern has been shown in Annex 9.

Table 8 Crop Coefficients for Proposed Major Crops.

	Months/Crops		Jan		Feb		Mar		Apr		May		June		July		Aug		Sep		Oct		Nov		Dec	
			1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
	Crop Coefficient (Kc)																									
1	M Paddy	MP														1.10	1.10	1.10	1.10	1.05	1.05	0.95	0.95			
2	S Maize	SM						0.60	0.80	1.05	1.05	1.05	0.80	0.80	0.80	0.80										
3	W Vegetables	Wve	0.86	0.95	0.95	0.89																		0.28	0.34	0.54
4	W Potato	WPo	0.79	1.01	1.13	1.13	1.08																	0.42	0.42	0.55
5	M Vegetables	Mve													0.34	0.54	0.93	1.05	1.05	1.04	0.91					
6	S Vegetables	Sve					0.34	0.54	0.93	1.05	1.05	1.04	1.04													

5.0 AGRICULTURAL DEVELOPMENT PLAN

5.1 Existing Agricultural practices

5.1.1 Existing Land Use

105 Most of the land in the study area of Kaligandaki, Marsyangdi and Madinadi terraces is cultivated. But most of the cultivated area has no irrigation facility. Due to the nature of the high terraces of these basins, water holding capacity of the cultivated land is low. Farmers have extensively developed small irrigation channels wherever it is possible. The land use of cultivated land is presented in Table 9.

Table 9 Land Use Pattern

S. N	Land use Type	Area (ha)	Percentage
1	Cultivated land	1366	100
2	Partially Irrigated land	303	22
3	Rain fed land	1063	78

Source: Field Survey, 2016

5.1.2 Cropping Area and Cropping Intensity

106 The major crops grown in the study area are paddy, maize, pulses, oilseeds, and Potato. Maize dominates the present cropping pattern covering more than 72 per cent of the area. Paddy is cultivated in partial irrigated parts of the Clusters area.

Photo 3 Fallow land after maize

Photo 4 Land Prepared waiting for rainfall

107 The details of cropped and cropping intensity are presented in Table 10. The cropped area and cropping intensity varies from cluster to cluster based on rainfall situation. The average cropping intensity of the whole area is estimated to be about 108.43 percent.

Table 10 Existing Cropping pattern and intensity at cluster level

Name of Cluster	Number of the System in Cluster	District	Crops					Total Cropped Area	Cropping Intensity
			Paddy	Maize	Potato	Oilseed	Pulses		
Madinadi 1	6	Tanahu and Lamjung	120.02	296.54	74.14	2.4	0	493.095	118.37
Marsyangdi 1	2	Gorkha	136	344	0	0	17.2	497.2	103.58
Kaligandaki 1	9	Palpat	46.52	422.28	0	0	21.11	489.91	104.50
Project level	17		302.54	1062.82	74.135	2.4004	38.314	1480.21	108.41

108 The cultivated command areas in all the three clusters are presented in Table 11. Altogether 17 systems are studied.

5.2 Crop Yields

109 The average (based on the area of coverage) crop yields of major crops as reported by farmers in the Project Clusters areas are presented in Table 11. These yields are compared with district Average. Almost all the yields are below district average crop yield at cluster level .

Table 11 Average district level (rain fed)

CROP Yield T/ha		Paddy	Maize	Black gram	Potato	Oilseed
Madinadi 1	Cluster level	2.5	2.75	0.5	13	-
	District level	2.9	2.5	0.6	19	-
Marsyangdi 1	Cluster level	2.15	1.25	0.45	-	-
	District level	2.5	1.5	0,5	-	-
Kaligandaki 1	Cluster level	2.75	2.5	0.7	13	0.5
	District level	3.2	1.88	0.82	20	0.78

Source: For district level DADO office of concern district

5.3 Crop Varieties

110 Crop varieties are mainly recommended from the research. The seed replacement rate is very poor. In case of paddy farmers prefer Makwanpur-1, Sukkha-1, Sabitri and Radha in all the clusters. Mankamana, and Rampur Composite are the maize varieties used by the farmers. Local variety Kalu Blackgram and local variety oilseed are in use. In Potato mainly Kufrijyoti is in practice.

5.4 Input use

111 In case of paddy and maize farmers are using Chemical fertilizers with FYM. But they are not using the required quantity. Farm yard manure is used in paddy, maize upland Potato and in others in oilseed and black gram. The details of Inputs quantity, Labor with types, and prices of input and outputs are presented in Table12-13-14 &15.

112 Most of the farmers use Bullock with operator. In recent days, mechanization (Tractors/power tillers) practice is started tractor for land preparation in some areas due to labor shortage.

Table 12 Present Agricultural Inputs for Crops grown

Particular	Unit	Paddy	Maize	Potato	Oilseeds	Blackgram
Seed	Kg/ha	45	26	1500	10	40
Farm Yard manure	Kg/ ha	1200	1400	3000	2000	3000
Urea	Kg/ ha	50	50	40	-	-
DAP	Kg/ ha	15	20	30	-	-
Potash	Kg/ ha	15	10	30	-	-

Source: Field survey 2016

Table 13 Present Agricultural Inputs for Crops grown

Particular	Unit	Paddy	Maize	potato	Oilseeds	Black gra15m
Labor- Human	No/ ha	125	110	150	50	50
Animal with operator	No/ha	16	8	8	15	15

Source: Field Survey, 20016

Table 14 Present Agricultural Inputs Prices for Crops grown

Particular	Unit	Paddy	Maize	Potato	Oilseeds	Blackgram
Seed	NRs/Kg	45	100	60	200	200
Farm Yard manure	NRs/Kg	1.50	1.50	1.50	1.50	1.50
Urea	NRs/Kg	25	25	25	-	-
DAP	NRs/Kg	51	51	51	-	-

Particular	Unit	Paddy	Maize	Potato	Oilseeds	Blackgram
Potash	NRs/Kg	40	40	40	-	-

Source: Field survey 2016

Table 15 Present Prices of Farm Labour and Main Products

Particular	Unit	Paddy	Maize	Potato	Oilseeds	Black gram
Labor- Human	Rs/Day	500	500	500	500	500
Animal with owner	Rs/Day	1200	1200	1200	1200	1200
Main Products	Rs/Kg	35	45	20	125	195

Source: Field Survey, 20016

5.5 Cropping Program

113 The existing cropping practice is based on the use of land resource in the condition of monsoon. Being monsoon rain based crops; their yield is varying in nature depending on the rainfall of the particular season. In comparison to other clusters, the worst condition is in Cluster -2. During the field survey, farmers expressed their willingness to shift from cereal to non-cereal crops, which have high market value. Hence, it has been proposed that non-cereal crops be introduced in the study area. Vegetables are the most commonly adopted crops as these crops can be chosen to suite conditions in a wide variety of hill climates.

114 During the field visit innovative youths were visited who are trying to cultivate vegetables even taking the land in lease and lifting water for irrigation.

Photo 5 Using drip irrigation for water efficiency use in Chyangli

Photo 6 innovative farmer using modern technology

115 The proposed cropping is based on 100% utilization of land during the pumping hour and season i.e. mainly pre-monsoon (summer season) and after monsoon (winter and spring season). Partially irrigated land and upland use paddy and maize. Based on this condition the pumped irrigation will facilitate to use the land for various high value crops mainly vegetables and potato. Thus the proposed cropping pattern for the project at cluster level is in table-16.

Photo 7 Failure of nursery at Chyangli's farmers' field

5.6 Proposed Cropping Practices and Calendar

116 As mentioned earlier, the existing cropping practices have to change over to new crops such as vegetables and potato which are able to give more return in relation to water input. It is expected that farmers will grow vegetable crops using various irrigation technology. The proposed cropping practices and calendar is presented in Table 16.

Table 16 Proposed Cropping Practices and Calendar

Main crops	Calendar
a. Winter vegetables	Dec - March
b. Summer vegetables	April - June
c. Potato	November-March
d. Tomato	June - October

Source: Agriculture Development Profile of Gorkha, Tanahu, Lamjung and Palpa district, 2014

5.7 Vegetable Crops and their Varieties

117 Due to its lucrative and quick returns, vegetable farming is becoming more popular in Gorkha, Tanahun, Lamjung and Palpa districts. Due to the road connectivity farmers of the study areas, can get significant benefits from vegetable farming. It is proposed to go for vegetable cultivation as given in Table 17.

Table 17 Vegetable Crop Varieties

S.N.	Vegetable crop	Proposed varieties
1	Cauliflower	Kathmandu local, Snow crown, Snowball-16, Madhuri, Silver cup-60, Rami
2	Cabbage	T-621, Green coronet, Green stone
3	Tomato	Roma, Navin, Manisha, Snehalata, C.L-1131, B.L-410, Greko-1, Greko-4

S.N.	Vegetable crop	Proposed varieties
4	Raayo	Khumal Ratopat, Khumal Chaudapat, marpha Chaudapat
5	Capsicum	Kathmandu local, California wonder
6	Potato	M.S-42, cardinal, T.P.S, Kufrijyoti, janakdev

Source: Agriculture Development Profile of Gorkha, Tanahu, Lamjung and Palpa district, 2014

5.8 Proposed Cropping Pattern

118 The proposed cropping pattern is based on the prevalent vegetable farming sequence in the area, which will be supported by adequate farm inputs. The main crop is vegetable both in the summer as well as in the winter with tomato as another cash crop.

Paddy-Potato- vegetable
Maize- Vegetable- vegetable
Vegetable-Vegetable-Vegetable

5.9 Proposed Cropped Area and cropping Intensity

119 Proposed cropped area and cropping intensity is given in Table 18 In all the clusters, the proposed cropped area is 3457.95 hectares. With the project, the cropping Intensity is 253.14 per cent.

Table 18 Proposed Cropped Area and cropping Intensity

S. N.	Crops	Coverage	
		With Project	
		Cropping Intensity (%)	Cropped Area (ha)
1	Summer Paddy	17.11	233.7
2	Maize	33.93	463.5
3	Tomato	56.50	771.8
4	Cauliflower	58.93	805.0
5	Cabbage	38.23	522.2
6	Potato	36.51	498.7
7	Capsicum	11.93	163.0
Total		**253.14**	**3,457.95**

5.10 Farm Inputs and Support Services

120 For the proposed vegetable prevalent cropping sequences, improved inputs and reliable support services are essential. District Agriculture Development Office has been providing support service as and when required. Besides this, private sector like agro vets is providing technical support and inputs. In line of value chain approach intervention (ADS), the Departmental and private sector support seems bright. Farmers can be benefited from recent government policy of one agriculture technician in one village.

121 At district level all districts have districts level offices followed by agriculture service center and. Agriculture sub-service center As Chandravati agriculture service center with Kayamin Agriculture sub-service center in the case of Tanahu and in the case of Bhorletar of Lamjung Bhorletar agriculture service center with Soti Pasal Agriculture sub-service center, Mirkot Agriculture Service Center and Rampur Agriculture Service Center are the centers which provide Agricultural Support Services in Clusters 1, 2 and 3 respectively.

Table 19 List of Agriculture Center and Sub-centers

Service Provider Location			Cluster
DADO	ASC	ASSC	
Lamjung -Besishar	Bhorletar	SotiPasal	1-Lamjung /sector
Tanahu-Damauli	Chandravati	Kayamin	1-Tanahu/sector
Gorkha-Gorkha Bazar	Mirkot	-	2- Changlitar
Palpa-Tansen	Rampur	-	4- Bhalyatar

Source: Agriculture Development Profile of Lamjung, Tanahu, Gorkha and Palpa district, 2015

5.11 Market

122 Based on the Principles of economics, when there is excess supply of produced commercial crops there will be drastically reduction in market price. Similarly, when there is shortage in production, there will be then demand will be high in local market and the price will go higher and higher. Commercial Producer produced required quantity according to market demand. There will be stability in market price when production planning and sound market linkages are established among the producers, traders or middlemen, retailers. If the good marketing mechanism is not developed, then the farmers will not get the justified price and then they may be discouraged to go for the cultivation of the particular crop in the next season. There is high demand of vegetables in Kathmandu, Pokhara, Butwal, and neighboring headquarters of the districts. Neighboring towns in border areas of Nepal and India also can be good markets for off-season vegetables. Development of connecting road networks in the cluster area it is easy for the farmers to access to market and services.

6.0 SOCIO-ECONOMIC PROFILE AND SOCIAL SAFEGUARD

6.1 Demographic Characteristics

123 The proposed clusters are densely populated with a total population of about 15120. The population of females is slightly higher by 1% than that of males. The average size of family is 6.2. Table 20 shows the number households and population of the Cluster level area according to its VDC location.

Table 20 Demographic Status of Study Area

Cluster	HH	Population	Family size
1	780	5070	6.5
2	1350	8100	6.0
3	300	1950	6.5
Total	2430	15120	6.2

Source: Field Survey, 2016

6.2 Ethnic Composition

124 Kumal ethnic groups make up the majority (50-70%) population at the cluster level 1 and 2. Where as in cluster-3 the majority ethnic group is Magar (30%) followed Brahamin (30%) by of the project area. As these settlements are densely populated and active in socio-economic enterprises, most of the Newar, Brahmin and Chhetri population are busy in non-agricultural occupation. Some of them have moved outside the project area for economic activities like services. The ethnic composition of the project area based on cluster level is presented in Table 21.

Table 21 Ethnic Composition of Study Area

Ethnic Group	Cluster-1		Cluster-2		Cluster-3		Total	
	HH	%	HH	%	HH	%	HH	%
Brahmin	78	10	135	10	90	30	303	12
Chhetri	78	10	68	5	75	25	220.5	9
Kumal	390	50	1013	75	0	0	1403	58
Magar	195	25	0	0	105	35	300	12
Newar	0	0	0	0	15	5	15	1
Damai/ Sarki	39	5	135	10	15	5	189	8

Ethnic Group	Cluster-1		Cluster-2		Cluster-3		Total	
	HH	%	HH	%	HH	%	HH	%
TOTAL	780	100	1350	100	300	100	2430	100

Source: Field Survey, 2016

6.3 Land holding pattern

125 The majority of farmers in the study area are small farmers having landholdings less than 19 ropani (1 ha) and mostly cultivated by them self. But some farmers are absentee farmers especially in Cluster-2 and cluster-3, and they have leased out the land in crop sharing and even started to provide in cash based on per ropani. The tenancy status is more or less uniform throughout the study area. Of the total 2430 farming families 35 percent have land in excess of 1 ha and the majority (60%) with less than this. These are mostly farmers from the Kumal, Magar, Damai and Sarki ethnic group. The details of landholding pattern are presented in Table 22.

Table 22 Detail of Landholding Pattern

S.N.	Landholdings	Households	Percentages
1	More than 1 ha	354	14.55
2	Between 0.5 to 1 ha	497	20.45
3	Up to 0.5 ha	1458	60
4	Land less	122	5
	Total	2,430	100

Source: Field Survey, 2016

6.4 Food security Status

126 Due to the rain fed condition of the cluster mostly (90%) of the households have food (Cereal grains) deficit from 7-9 months from own farm product in spite of the farm size. The Cluster 2 faces more than 9 months and cluster 3 faces for 7 months.

Table 23 Food sufficiency Status

Food self sufficiency	Unit	Cluster-1	Cluster-2	Cluster-3
	Month	4	3	5

Source: Field Survey, 2016

6.5 Gender

127 The pre- feasibility study conducted in the project area reveals that the status of women in the project area is low and significant gender inequalities continue to persist. Due to poor access to health and education services, productive employment opportunities and land ownership, we can see the lowest level of gender equity. The main gender issue in irrigation is that fewer women participate in this sector. It is due to the cultural belief that this role is for men, even though women are able to participate and work in this sector. This led to women not being motivated to participate in this sector. The other reasons are the attitude of men (husbands) not allowing the women (wives) to work with other men and that women's having reproductive workload of taking care of the children, cooking, cleaning the house and managing the farm while their husbands or parents go abroad for jobs.

128 The gender aspect related to lift irrigation can be understood by first knowing how the irrigated production is organized within the household both in terms of labor input and decision making. With regard to agricultural operations, men tend to carry out the technological and highly production augmentation tasks, like ploughing and fertilizer and pesticide application. Men are also exclusively performing the task of marketing. Women on the other hand tend to be most involved in the unskilled and labor intensive tasks like land preparation, planting, weeding, harvesting and threshing, either alone or jointly with men

129 Men have the main role in making decisions over issues like crop selection, application of pesticides and fertilizers, hiring and buying of tools and plants; and leasing land and taking credits. However, they take advice from their spouses in most of the cases.

130 Women need to walk long distances to obtain water, fuel (fire wood), and fodder for washing vessels, cooking, bathing purposes and feeding livestock respectively. After having irrigation facilities from lift schemes, men can be engaged to grow fodder for the cattle in a special part of irrigated field, then both men and women can take care of the cattle. Water for crops and the cattle can be made available when needed. Then, women may have more time to devote to other activities including literacy, health care, women's groups and other income generation schemes.

131 Lift Irrigation management issues should be mainly discussed in focus groups of beneficiaries including women participants. A qualitative picture can be obtained from these discussions. The issues discussed can encompass the general tasks that each farmer and each member of the irrigation beneficiary should carry out besides applying water to the field itself, such as following-up on demand for water, depositing water charges, filling forms for demand of

water, participating in general body meetings, being informed about decisions of these meetings (like water rates and rotation schedules, etc.).

132 The load shedding of electricity supply during the day may force many schemes to irrigate most of the time during the night. Thus, irrigating the field during night time might cause difficulty to single women especially widows. Widows prefer to have the water supplies during the day.

133 In the community managed systems, before the irrigation season, the earthen field channels are cleaned and repaired. Mostly women do this work. Male members of the community generally would like to perform the tasks like maintenance of the pumping system and main canals. In case of scheme-level conflicts, women may participate in scheme-level irrigation management and conflict resolution as well.

134 It would be better if training on leadership and management be conducted on the beneficiaries especially for women to sensitize members on the role of women in irrigation activities. At the community level, women should be encouraged to participate in various Water Users Association meetings, training and study tours. Also, efforts should be made to make exposure to women on various aspects of irrigation activities. The communities should be trained to give wider recognition to importance of women in irrigation efforts. However, it may take time to change the thinking of the beneficiaries. In most of the schemes, it is found that irrigation management at the committee level remains almost exclusively dominated by men.

135 Women beneficiaries should be encouraged to conduct income generation activities like savings and credit, milk production, floriculture, or vegetable cultivation from irrigated agriculture.

136 Irrigation is a task that men and women perform together in majority of the cases. In most of the cases, men assume the responsibilities of water management tasks. Women are reluctant to take the managerial and operational level responsibilities. In some cases, the women who do perform such managerial tasks are generally treated in the same footing as men. Training and empowerment to women are necessary to make them participated in the lift irrigation activities.

137 There is a need to intervene at the household level for improving women's participation in the project activities and thereby improve status. During Feasibility Study, the Gender and Poverty Implementation Plan (GIP) has to be prepared to maximize project benefit to the women, poor households including ethnic minorities and disadvantaged low caste groups in the command area. This plan is expected to ensure gender equality and social inclusion in various stages of the project implementation.

7.0 PROPOSED IRRIGATION DEVELOPMENT PLAN

7.1 General

139 Rivers, ponds, spring water are the main sources of water for conventional irrigation systems. These systems are based on gravity flow canal networks. There is substantial potential land that is difficult to irrigate through this prevailing conventional irrigation technology. Now it is felt necessary to introduce other possible methods for irrigation in such areas. Stream water harvesting, rainwater harvesting, lift from rivers are considered as feasible methods. The study area of these basins is lacking sufficient surface water resources for conventional irrigation practices. Therefore, the proposed irrigation development plan considers the introduction of lift irrigation technology and diversification of irrigated agriculture. The major focus of this lift technology is to enhance non-cereal crops, which require efficient use of available water for plant growth. The following headings describe the proposed lift irrigation scheme and their possible application in the study area.

7.2 Lift Irrigation from Kaligandaki, Marsyangdi, Daraundi, Madinadi Basins

140 As discussed above three clusters Madinadi 1, Marsyangdi nadi 1 and Kaligandaki 1 clusters are chosen for further study. The crop water requirement calculations, hydraulic design of the systems, are done for each cluster on the representative basis as discussed in 4.2 paragraph 101. The total command areas of each cluster are presented in the Table.24

Table 24 Cluster Wise Gross Command Area

Name of Cluster	Number of Systems	District	Gross Command Area
Madi-1	6	Tanahu Lamjung	520.7
Marsyangdi-1	2	Gorkha	600
Kaligandaki 1	9	Palpa	586
Total	17	4	1706.7

Source: Field survey, 2016

141 Intake well, intake pipe, delivery pipe, a pump house, electric panel board, rising main and distribution system are the main components in a lift irrigation scheme.

142 Intake structure: The intake structure is a sump well type structure built on the edge of the river. The size of intake in the location where it has been proposed is 3.4 m in diameter with an average depth of 6 m from the riverbed. In this case it is assumed that the fluctuation of

flow is about 3 m during monsoon and winter. The intake is designed keeping this fact in mind.

143 Pump house: We are using submersible pumps. Therefore, pumps will be in the well. In the pump house the panel board is kept for all the pumps. The pump house is a small shed for the protection and operation of the pumps and panel board and other accessories are placed in this house. This house is located on the bank of the river at safe place.

144 Design of pump and motor: There are a few essential details that must be determined before the design of a pump. In the case of centrifugal pumps, there will essentially be two types of heads i.e. the suction head and the delivery head. These two heads are known as total head. The suction head is the head that the pump must overcome from the point of intake to the point where the fluid reaches the pump. The delivery head is the head that the pump must overcome from the pump point to the place where the fluid is to be delivered e.g. a tank or reservoir. Both these heads will also include losses such as loss in entry/ exit, loss in bends and fixtures, loss in flow friction etc. just to name a few. In submersible pumps, there is no suction head. The capacity of the pump is calculated based on the formula:

$$P = \frac{\rho * g * Q * H}{n_p} Watts$$

Where,

ρ = unit weight of fluid being pumped in Kg / m3

Q = required design discharge of the well in m3

H = total dynamic head in m

g = gravitational acceleration (9.81 m / sec2)

η_p = pump efficiency

H = head loss in suction + water surface fluctuation + depth to water surface + difference in elevation + losses during delivery

145 Pump Design: Tars in project area are located at various altitudes, where need of irrigation for farming system improvement is must. In this regard, an attempt is made in improving the irrigation facility with the help of designing the pump for lift irrigation. In this regard the cost and benefit of the systems with different heads and command area, out of the 55 systems (para-79), the following four systems are taken as representative (Table-25). Baireni (Kumaltari) having 40 m head, Chyanglitar having two step tars (55m and 112 m head), Aanpchaur having two steps tars (105 m and 92 m heads) are taken as representative tars. Chyangli tar of Gorkha district is divided into two parts - one is Chyangli High land and the other is Chyangli low land. The head for Chyangli high land is high, therefore two stage lifting are proposed- Chyangli high land (1) and Chyangli high land (2) for pump designing purpose. Similarly, the head of Aanpchaur is 197 m. Therefore, two stage lifting are proposed for this system as well.

Table 25 Tars having different heads taken for design purpose.

S.N.	Name of System	Name of Basin	Head in meter	Net Command Area, ha	Remarks
1	Chyangli Low land	Marsyangdi	55	336	
2	Chyangli high land (1)	Marsyangdi	60	144	First Lift
3	Chyangli high land (2)	Marsyangdi	52		Second Lift
4	Baireni (Kumaltari)	Madi	40	65.12	
5	Aaanpchaur Low	Kaligandaki	105	70.16	First Lift
6	Aaanpchaur High	Kaligandaki	92	24.04	Second Lift

146 Based on the water requirement of crops, the duty of 0.5 lit per sec per hectare is taken for the design purpose. Pumps are designed for these six systems. Design of pumps and pipes are given in Annex10, Pipe Lengths is given in Annex 11. Based on this design the pump details are given below in Table 26. For the design purpose, an Agri- catalogue of pumps is used which is given in Annex 20. Design The pump details are given in following Table 26

Table 26 Pump Design Details

S.N.	Name of System	Name of Cluster	Head in meter	No of pumps	Type of Pump	Capacity of Pump		Pipe Diameter mm	Net Command Area, ha	Remarks
						KW	HP			
1	Chyangli Low land	Marsyangdi 1	55	14	Submersible	15	20	100	336	
2	Chyangli high land (1)	Marsyangdi 1	60	6	Submersible	15	20	100	144	First Lift
3	Chyangli high land (2)	Marsyangdi 1	59	6	Submersible	13	17.5	100	144	Second Lift
4	Baireni (Kumaltari)	Madi 1	40	2	Submersible	15	20	100	65.12	
5	Aaanpchaur Low	Kaligandaki	105	6	Submersible	15	20	80	70.16	First Lift
6	Aaanpchaur High	Kaligandaki	92	2	Submersible	13	17	80	24.04	Second Lift

147 For Chyangli Low land, 14 pumps are accommodated in 3 intake wells as – 3 numbers of pumps in each four wells and 2 pumps in one well. For Baireni (Kumaltari) two wells are placed in one intake well. For Chyangli highland, 6 pumps are placed in two intake wells. In Aanpchaur 6 pumps are accommodated in two intake wells.

Choice of Pumping System

148 Wide range of pumps is available in the market. Selection of right pump for the right use, depends on a series of inter related factors. Most commonly used pumps are horizontal end suction, vertical submersible and vertical turbine pumps. Mixed or axial flow impellers are sometimes used in low lift, high capacity operations like lifting of water from a canal. The factors that affect the decision one way or the other to select a particular pump are listed below:

- Capacity
- Head
- Working pressure
- Efficiency range
- Nature of water to be lifted
- Fluctuation of pumping water level
- Suction conditions
- Shape and size of the water extraction structure
- Quality of water
- Choice of driving power
- Fluctuation of loads
- Floor space available
- Priming Requirements
- Accessibility and protection of the pump
- Initial cost
- Operating cost
- Reliability
- Flexibility
- Availability
- Acceptability

149 Depending on the area to be irrigated and head, complete layout of the system is finalized. All components of the system including valves, bends, manifolds, reducers, etc. may be incorporated for evaluating total head for each pumping, summing up static head and friction head. Market survey for various types of pumps and their availability will help to identify cost-effective pump for a given site. In our case, we use electrically driven pumps. In the case of electrically driven pumps, directly coupled AC motors are generally available in the market. While selecting a pump, it is tried to have the possible adequacy between power, required discharge and head.

150 Selection of pump on the basis of discharge capacity required for a given system conditions (head requirement) can often determine the pump type. The greatest number of alternatives is usually available in the smaller capacity ranges. Hence, efficiency, initial cost and running cost may be the primary factors.

151 The choice of the pumping system can be broadly discussed under following headings:

- Financial and Economic Considerations
- Practical Considerations
- Other considerations

a. Financial and Economic Considerations

152 The ultimate criterion for choosing an irrigation pumping system is to obtain the most "cost-effective" system; this does not necessarily mean the "cheapest" system, since low first cost often results in high running costs. To arrive at a realistic assessment of the true cost-effectiveness is not easy. Reliability, availability of spare parts or maintenance skills, ease of use and vulnerability to theft are some factors which have cost implications, but which are difficult to factor in to any cost analysis. Financial or economic appraisal of options generally represents the primary criterion for selection; this should not necessarily be used as the sole method for selection. The final selection generally needs to be based on technical or operational considerations.

b. Practical Considerations

153 Some technologies are more easily “available" than others. Some are obsolete. Farmers generally like to have the system which they feel convenient for operation. They do not like complicated system.

154 Level of support available from manufacturers or suppliers is most important; most successful technologies have become widely used because they were successfully promoted and supported by the commercial interests that market them.

155 Often there are trade-offs between the amount of skill needed and the amount of maintenance/operational intervention required. Training is a vital aspect of introducing any new or unfamiliar technologies. Durability, reliability and a long useful life usually cost money. In most of the cases, they are frequently a good investment in terms of minimizing costs on the long run. Perceptions on the value of capital or the choice of discount rate will usually control decisions on these aspects. However it is best to try and show through economic or financial analysis whether the benefits from buying high quality equipment are cost-effective.

b. Other Considerations

156 while selecting a pump also we should also look for the following advantages in a pump:

- Highest Efficiency
- Greatest Reliability
- Widest Range of Operating Capacity
- Longest Life
- Lowest Price

157 In addition to the above considerations in our case, the following factors are also considered:

- The pumps and their spare parts should be easily in the local market.
- The projects are planned in the hilly areas and in view of maintenance acceptability at the time of breakdown of pumps; it will be easier to handle smaller size pumps rather than big pumps.
- In case of smaller pumps, whole set of pump and its parts can be used in the place of broken pump. Amount involved in the replacement and repair of the set is lower for the smaller pumps in comparison to big ones.
- In case of replacement at future, low cost will be involved for smaller size pumps.
- Water Distribution management can be done easily by farmers for about 25 hectares of land. Therefore, one or two pumps for 25 hectares is practically suitable.
- If big capacity pumps are used, at the time of breakdown, big chunk of land will be deprived of irrigation. Planned cropping calendar may fail.
- For repair of big pumps, we have to go to the manufacturer for repair. Even for small parts, we have to consult him. and special order should be placed for the spare parts
- Farmers' attitude is also a factor to be considered, because they have to operate and maintain the system in future. In our case they prefer smaller size pumps rather than single big capacity pumps.

158 Considering all the above factors, we have chosen to go for submersible pumps of capacity between 13 to 15 KW pumps as per technical design for maximum efficiency and optimum use. These proposed pumps are readily available in the nearby markets.

159 The sustainability of the scheme will depend on the smooth operation and maintenance of the pump. Now there are plenty of good workshops manned by technically competent staff for the periodic maintenance of pumps.

8.0 PROJECT IMPLEMENTATION ORGANIZATION AND SCHEDULE

8.1 Project Organization

160 DOI will be the main implementing and executing agency for the proposed Mid Hill Lift Irrigation Project. There should be three levels of implementation units within DOI with the coordination of different line agencies. The implementation units should be (i) A central level Coordination Committee (ii) The Project Management Office (iii) District Coordination Committee.

161 The Central Level Coordination Committee (CC) should be established with the responsibility for the project guiding, and inter agency coordination. This committee shall coordinate with the other ministries and authorities for the timely execution of the project. This committee will review project progress and resolve implementation issues. This could be headed by Deputy Director General (DDG) of Department of Irrigation.

8.2 The Project Management Office

162 The Project Management Office (PMO) shall be established under the leadership of a senior Irrigation Engineer. This Office should have overall responsibility for project implementation. This unit should have 3 divisions for the implementation of the Project. They are namely; (i) Technical division (ii) Institutional development division and (iii) Administrative and Finance division. All the divisions should be headed by an experienced full time staff (Engineer) with adequate professional and support staff.

163 At district level, Concerned District Division Offices should coordinate with Project Management Office (PMO) for implementation of the Project.

8.3 Role and responsibilities of Concerned District Division Offices:

- Review design, and verify quantities and cost of projects,
- Check construction quality of project
- Maintain project account at a district level
- Take measurement and release payments to WUAs or contractors
- Provide necessary trainings for beneficiaries in project areas
- Monitoring technical support teams, district coordinators, and village-based field teams in sub system implementation

164 A District Coordination Committee should be established at the district level with the responsibility to coordinate and facilitate the implementation of the planning, construction and support activities.

165 Under the Direct supervision of the Department of Agriculture, the District Agricultural Office would be responsible for the implementation of the agricultural support program.

166 Consultant services with local specialists should be engaged to assist the implementation of the Project.

8.4 WUA Involvement in Construction, Operation and Maintenance

167 For sustainability of any program, self-reliance, local ownership and genuine participation of beneficiaries are the main basis. In this context, involvement of beneficiaries in the form of Water Users Association (WUA) is essential right from the beginning of the project cycle. Their participation in choosing the location of intake, pump house, panel board house, canal alignment, distribution boxes, etc. should be insured.

168 WUA's role in managing the water distribution equitably as per the demand of the farmers is important. Besides, agricultural aspects, record keeping of pump operating hours, regular maintenance of the pumping system, water charge collection system are some of the areas where trainings to WUAs are needed. For the proper operation and maintenance of the project, WUA should train their operating personal.

169 The beneficiaries and WUA will be trained and empowered to control the resources and make their own decisions, undertake the responsibilities and supervise the irrigation system of their own that will finally support towards the sustainability of the irrigation system in terms of technology, finance and organizing capability of beneficiaries.

170 The beneficiaries will be organized into various functional groups which will help them to explore their potentialities for managing the system in self-sustained basis. The irrigation system after completion will be handed over to the respective WUA for local ownership, operation, repair & maintenance and sustainability of the project. WUA will be made more responsive in system operation.

8.5 Implementation schedule

171 Implementation arrangement is given in Figure 2. The overall project period is taken as 3 years 4 moths. First, the detail Feasibility Study will be started from November 2016 and it will be completed within six months. In the implementation of the project, WUA's participation plays important role. During feasibility study period, WUA formation, training to them on monitoring and quality control will be taken up simultaneously. Civil works procurement process will start after approval of the Project Report. Construction of intake well and pipe canal system will start simultaneously. Electro-mechanical works will be started towards the end of civil construction parts. The project is assumed to be completed within three years' time period. A tentative implementation schedule is thus prepared to accomplish the task in timely manner. (Annex-12)

172 As per the Terms of Reference of assignment, we have prepared a TOR for Detail Feasibility Study which is given in Annex 19.

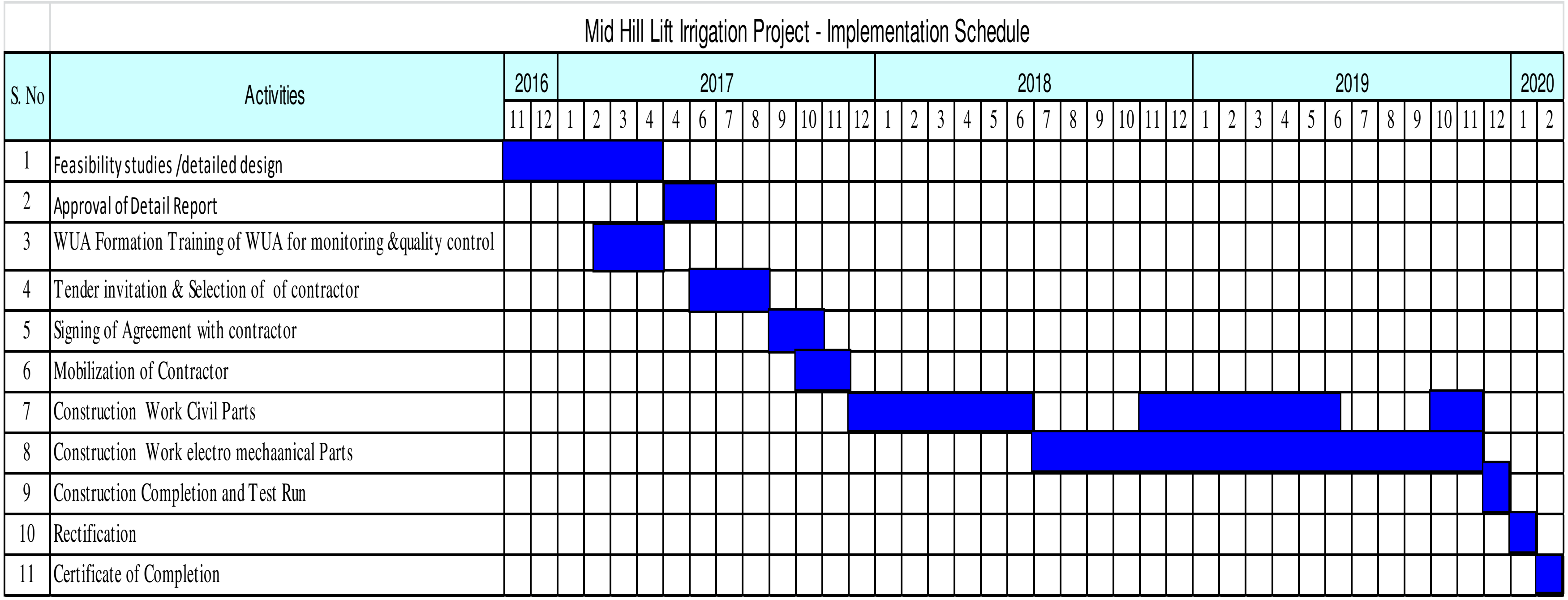


Figure 2 M id Hill Lift Irrigation project implementation Schedule

9.0 ENVIRONMENTAL ASSESSMENT

9.1 Environmental Consideration:

173 According to Environmental Protection Rules 2054 of the Government, in Hilly Areas Environmental Impact Assessment must be carried out for irrigation projects having command area more than 500 hectares. For projects with lesser command area Initial Environmental Examination (IEE) will be sufficient. In our case, all the three clusters do not have 500 hectares of command area of a system individually. The command area of Chyangli low land (420 ha) is the highest. IEE is carried out using checklist of environmental parameters. In the checklist, actions affecting environmental resources and values are classified into headings. They are listed below:

9.2 Environmental effect due to the site selection

1. Encroachment into forests:

174 There is no forest in canal alignment and head works site. Therefore, for this category, the impact is ranked at D1 significance level.

2. Impediment to movement of wildlife, cattle and people:

175 All the areas in our study have no forest. The area is inhabited by the local people. There is no movement of wild life. The project will not affect movement of wildlife, cattle and people. So the impact is ranked at D1 significance level.

3. Impediment of historical / cultural, monuments buildings and values:

176 Such objects are not located in the project area. Hence, it is ranked at D1 significance level.

4. Conflicts in water supply rights :

177 There is no use of water of the source rivers upstream and downstream. So, possibility of such conflicts were not observed and ranked at D1 significance level.

5. Regional flooding / drainage hazards.

178 There are no chances of command area to be flooded. So for this category, the impact is ranked at D1 significance level.

9.3 Problems from oversight in planning and Design

1. Watershed erosion and sedimentation:

179 The watershed area falls in catchment of big rivers. The area is vast. There might be some problems of erosion and sedimentation in the catchment of these rivers. Based on the scale of the project, it is not possible to solve this problem.. So the impact is ranked at D1 significance level.

2. Suitability of water quality for irrigation:

180 There is no any big industry in the watershed area. So that water pollution problem is not a major issue. Water quality will not be deteriorated due to the sub-project implementation. hence, the impact is ranked at D1 significance level.

3. Adequacy of drainage planning:

181 The Command area has sufficient slope for proper drainage. Hence, the impact is ranked at D1 significance level.

4.Scouring hazards:

182 The river bed of Source Rivers at intake site possesses hard rock bed. Scouring hazards are not anticipated. Therefore, impact is ranked at D1 significance level.

9.4 Problems during construction stage

1.Soil erosion / landslides:

183 This is a new project located at hill terraces of river basins. Most of the construction activities will be concentrated in plain areas. Therefore, there will be least chances of soil erosion and landslides' impact is ranked at D1 significance level.

2.Monitoring during construction

184 Monitoring is necessary to achieve good quality of work. WUA and concerned project officials should strictly supervise during construction to achieve good quality of work.

9.5 Problems Stemming from Deficiencies in operation

1 Inadequate O & M:

185 Farmers of the project area should be capable for O & M of the system to prevent the loss in project efficiency. However, this is a new project; the farmers should be trained for proper O & M of the system after its completion. The impact is ranked at D1 significance level.

2.Adverse modification and changes in water table:

186 Since the command area is high land, adverse effects are not anticipated in this project and ranked is done at D1 level.

3.Use / misuses of agro-chemicals:

187 People of the sub-project mostly use organic manure and it is expected that farmers may use chemicals in future. Right from the beginning Agriculture Service Center should provide training to farmers to adopt organic farming practice rather than using chemical fertilizers and pesticides. No adverse effects due to use of agrochemical are anticipated and ranking is done at D1 level.

9.6 Realization of Enhancement Potentials

1.Community Water Supply:

188 The project area has water supply facility. So there is no need of additional abstraction for water supply

2.Micro hydroelectricity:

189 There are no micro hydroelectricity projects in the Source River.

3.Industrial Water Supply:

190 No industrial water supply schemes observed in the Source River.

191 Thus, it can be concluded that the project is environmentally sound and therefore support the long term sustainability. The checklist is given in Annex13.

10.0 ELECTRICAL POWER SUPPLY

10.1 Power Supply to the lift system

192 Most of today's electrical energy is generated by plant with a low cost of production and high reliability. In Nepalese Integrated Power System, hydro power plays vital role. Most of areas national grid is available. The parts of Kali-Gandaki, Marsyangdi and Madi Nadi River Basins have connectivity to National grid and the availability of electrical energy in the areas is more dependable even though other parts of the country are facing reeling electricity outage. Moreover, these parts lie in the areas where load shedding is very less or not at all due to the fact that there are Kali Gandaki Hydro Power Station in Palpa and Syangja Districts. In the same way, Middle Marsyangdi Hydro power Station and Marsyangdi Hydro Power Station are in Tanahu, Lamjung and Gorkha districts.

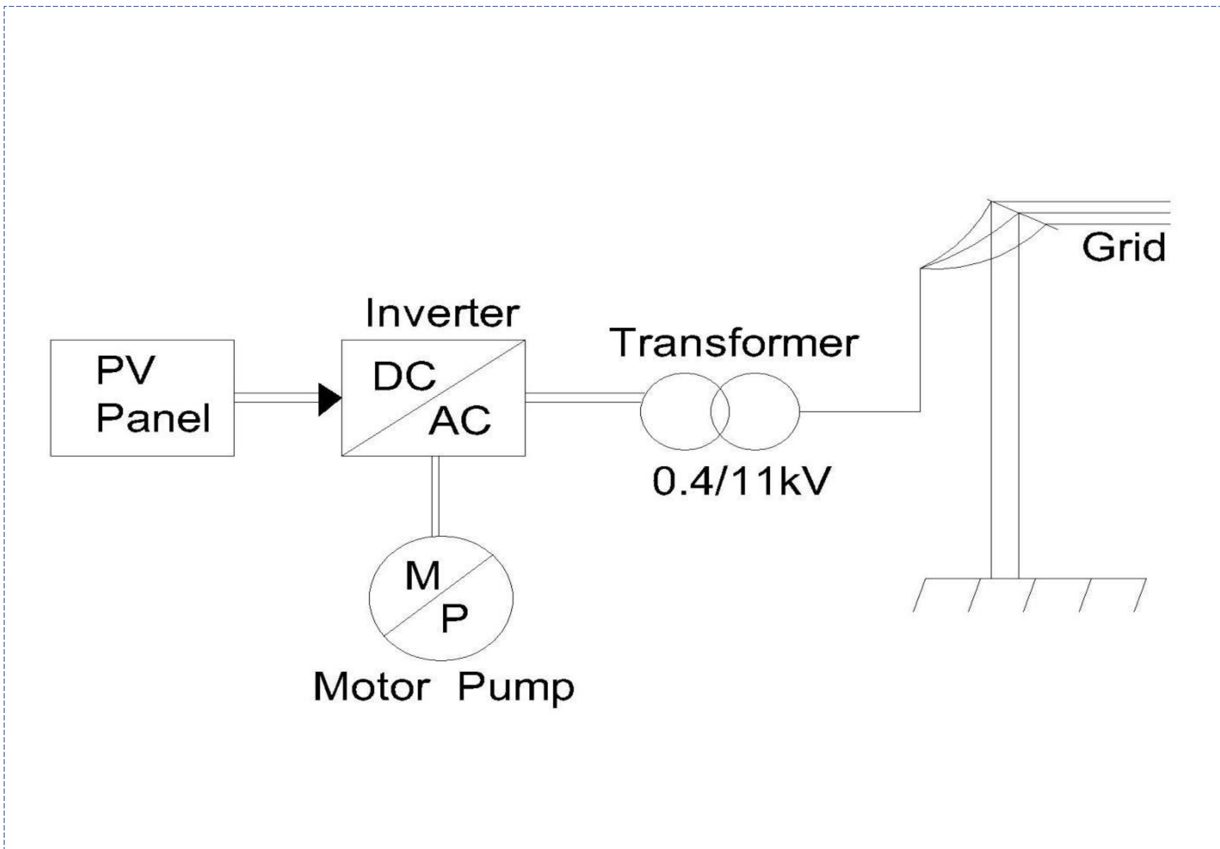


Figure 3 Schematic Diagram of Electrical grid connection and PV panels.

10.2 Solar Power:

193 As per the TOR, a second energy option- combination of solar energy system integrated with the national grid is proposed as given below.

194 In Nepal, 81% of electric power generation is provided by hydro, 18% imported from India and balance 1% from diesel. There is total installed capacity of 787 MW (NEA and IPPs) of installed capacity of generating plant . The Peak Demand of Nepal Integrated Power System in F.Y. 2014/015 was 1292 MW. The deficit load was load shedding of power in the system.

195 Most of today's electrical energy is generated by plant with a low cost of production and high reliability. However, concerns about the longer term sustainability of fossil fuel-based generation, particularly related to climate change and largely unaccounted future environmental costs, are driving the energy industry toward sustainable, low carbon emitting, renewable energy sources. Community expectation for this change is high and government policies are also driving the energy industry in this direction.

196 Solar energy is an unlimited energy resource, set to become increasingly important in the longer term, for providing electricity and heat energy on a large scale. It is an energy resource that could be used in large, centralized power generation plants; smaller distributed heat and power plants; or scaled down, at the individual consumer level. Solar energy technology is technically proven and draws on an inexhaustible primary energy resource. Carbon emissions and greenhouse gas impacts are very low.

197 About 45 percent of the total population, mostly from rural areas, is still deprived of electricity in Nepal. Owing to difficult terrain and sporadic distribution of rural households, the extension of grid electricity in a number of villages in the high mountain areas is very costly. Local min-grids from micro-hydro power plants are also not viable because of long transmission and distribution line network. Even in urban areas where households are connected with national grid, there has been an acute power shortage in recent years. Winter becomes worse with almost 14-hour daily load shedding.

198 The unreliability of grid electricity has been hampering people's everyday life and harming the industry as well as irrigation system. This reality compels Irrigation Department to look for solar photovoltaic technology as it has been proven to be a viable. Fortunately, solar photovoltaic (PV) technology has been gaining popularity in both rural and urban areas to meet the basic energy demand. Nepal receives solar energy ranging from 3.6 to 5.9 kWh/m2 per day and the sun shines for about 300 days. These figures indicate that Nepal has high potential of solar PV, which can be tapped to mitigate energy crisis in the irrigating land. PV technology collects and converts solar radiation directly into electricity.

199 PV module provides reliable power and it has many uses in various areas, which could help improve the socio-economic conditions of rural people. Electricity produced by PV system can be employed for Lift irrigation and lighting.

200 A solar panel is a packaged, connected series of photovoltaic (solar) cells that generates electricity. Solar cells are typically made of silicon and use the photovoltaic effect to convert the energy of sunlight (photons) directly into direct current (DC) electricity. An inverter is then used to convert the DC power to AC (alternating current) power, which is the kind of power used by the electrical grid and almost all non-battery operated electrical devices (whatever you plug into

the outlets in your home). Due to the relatively low efficiency of current cell technologies, each panel can only produce a small amount of power. Most installations require an array of panels.

Photo 8 Array of Solar Panels

201 Photovoltaic modules are usually either thin-film or crystalline cells on wafers of refined silicon and are protected from the elements by sheets of glass and metal frames. Silicon is used because it is a semiconductor. When the sun's radiation (a photon) hits a silicon atom, it can be absorbed and cause the emission of an electron. When many electrons are emitted inside a semiconductor, an electric current is produced. Silver or copper conductors draw the small currents off the entire array of cells and direct them into one output. Connections can be made in parallel to achieve a certain amount of current or in series to produce a desired output voltage.

202 Solar panels, which are made up of multiple modules, are either rigid or semi-rigid. Some systems only connect to a series of batteries that are used for backup power; they are connected to lifting pumps as well as the electrical grid. A complete solar energy system is made up of an array of units, an inverter to turn DC voltage into AC, a meter to track the power that is produced, a battery to store the energy and all the necessary wiring.

203 Crystalline panels are the most common type of PV panel. The technology has been around for about 50 years and was first developed for powering satellites. They are capable of being up to 20% efficient. Most of these technologies are highly reliable (25 year warranties are common) and produce similar results in terms of output efficiency. The primary downsides of using crystalline are that they can be bulky, expensive, prone to damage, are rigid and require a lot of labor to install. That said, they are often the best choice for use. They come in two varieties: monocrystalline and polycrystalline.

204 Monocrystalline silicon panels are made up of single-crystal wafer cells cut from continuous, cylindrical crystal ingots. They can be cut completely circular to minimize waste, but they are often trimmed into other, more square-like shapes. Since each is made from a single crystal, the cells have a uniform, deep blue color. They are the most efficient units available today (they produce more power per square foot), but they cost more than other types.

205 Polycrystalline silicon panels are made of multi-crystal wafer cells cut from square ingots that are created by pouring molten silicon into a mold. This way they can be cut into square wafers to minimize waste. Each is made up of random crystal formations which make it various colors of blue. They are slightly less energy efficient, but also cheaper than mono-crystalline.

206 The simplest configuration for a PV system is a fixed position flat panel module. Generally for 'all round' performance, the module is inclined at the site's latitude angle. A fixed flat panel system has no moving parts and offers the solution with the least ongoing cost of the PV options. Its output will however be less per module than the PV systems that track the Sun.

207 The panels will be ground mounted and tilted 10 degrees to face the sun. The ground mounting will require a flat level surface and will be set into concrete. The panels will require an area that is un-shaded from the sun. Any vegetation underneath the panels will need to be kept to a level below that of the panels in order to avoid shading.

208 All the panels will be at least 1.5 m from the ground. It is assumed that this is adequate to keep the panels above the flood height of the site.

209 The panels will be mounted in rows and electrically connected with cables. The cables will need to be made safe and tamper proof.

210 The electrical output from the PV panels will be fed via cables to a bank of inverters. The inverters will be housed in a structure to protect them from the weather and from tampering. A design decision based on cost will need to be made whether the inverters are all located in one area or are interspersed around the site.

Photo 9 Solar Panel

Ultra-Thin Solar Panel, Amorphous Silicon Solar Panel The size of solar panel is 1414*1114*35mm.

Photo 10 A Typical Substation Design to connect the solar power with the Nepal Integrated Power System.

10.2.1 Cost of Solar system

a. Capital cost

211 The forecast capital cost of a PV Grid Tied Solar Project in the Kathmandu Valley, is based on the recent evaluated bid price of three lowest bidders in PV Grid tied Solar Project, Tender No. PGTSP–068/69-01 funded by Asian Development Project, the executing body being NEA. The cost comprises of complete study, design, development, manufacturing, installation, testing & commissioning of plant.

212 The total capital cost for the 20,000 kWp Grid Tied PV Solar Plant would be US$ 50.85 million.

10.2.2 Cost Estimate of Solar power system:

213 The Cost estimate is made on the Basis of cost estimate Prepared by NEA on 2013. For the market inflation and adjustment an increment of 10% per year has taken into account.

214 Total estimate of USD 50.85 million was for 20,000kWp plant on 2013

Table 27 Total estimate solar plant

Fiscal Year	2012/013, USD/Wp	2013/014, USD/Wp	2014/015,USD/Wp	2015/016,USD/Wp
Cost/ Wp	2.5425	2.8	3.08	3.388

Cost of Battery in USD 22,000/100 kVA= USD 0.2222/VA

215 Operating and maintenance cost:

1. The estimated O&M cost has considered at the rate of 1.5% of capital cost/annum.
2. Operation and Maintenance cost is 1.5 % of capital cost=USD 3.388*0.0115 = $ 0.03896/ annum
3. Cost of Battery in USD 22,000/100 kVA= USD 0.2222/VA

216 The O&M cost is intended to cover the direct costs of plant operations and include:

- direct operating labour including operators on shift (2 per shift), supervisor, reflector cleaners (2) and maintenance staff (2);
- materials and consumables; and
- long term maintenance.

10.2.3 Operation and maintenance of Solar system

217 Typical works to be carried out during operation and maintenance would be as follows:

Table 27 Works to be carried out during operation and maintenance

S. No.	Details of maintenance requirements	Component typical activity
1	Solar array structure	Visual inspection for corrosion, damage and general integrity of structure. Removal of vermin.
2	Solar modules	Glass cleaning. Visual inspection for corrosion, damage and general integrity. Removal of vermin. Replacement of damaged modules.
3	Wiring and junction boxes	Visual inspection for corrosion, damage, such as chafing, damage by rodents and birds. Visual inspection for overheating of cables and connections.
4	Inverters	Monitoring of output and action taken if required at the inverter, wiring or solar module damage Visual inspection for overheating of cables and connections.
5	Safety devices	Checking connections, functionality of isolators and circuit breakers. Check for signs of overheating.
6	Land	General maintenance to keep land clear of vegetation that may shade the solar array or present a fire hazard or even reptile hazard.

218 The estimating and costing of solar system is separately done in the Project estimate file and is given in Annex15.

11.0 PROJECT COST AND ECONOMIC EVALUATION

11.1 Analysis of Rates

219 For the purpose of estimating cost of the project development in this pre-feasibility study, the analysis of rates is carried out based on approved district rates of concerned districts.

11.2 Cost Estimation

220 We have designed pumps for four systems as mentioned in para.145. Cost estimates are calculated for these designed tars- Chyangli High land, Chyangli Low land, Baireni (Kumaltari), Aanp chaur. The summary of cost is presented in Table 29 to Table 32 and detail of cost breakdown is attached in the Annex 14.

Table 28 Summary of cost of Chyangli High Land Tar

S.No.	Description of Works	Amount in NRs
A	Total Construction Cost	68,777,271.75
B	General Item	
	Insurance of works, equipment, contractor's workers and employees & Third party insurance against damage to other persons and property	1,000,000.00
	Preparation of as built Drawing	100,000.00
	Sub Total (B)	1,100,000.00
C	Contingencies	
	Work Charge (2.5% of A)	1,719,431.79
	Contingencies (2.5% of A)	1,719,431.79
	Physical Contingencies 10% of A	6,877,727.18
	Price Escalation Contingencies 10% of A	6,877,727.18
	Sub-total (C)	17,194,317.94
D	VAT (13% of A)	8,941,045.33
E	Provision for Environment Protection Cost	1,375,545.44
F	Total (A+B+C+D+E)	97,388,180.45
G	Cost per ha. (Total Cost)	676,306.81

221 Total cost of Chyangli High land Tar with solar is also calculated and for this Tar the cost is NRs. 189,093,037 and with solar the cost per hectare is NRs. 1,313,146.The detail of cost estimate is given in Annex 14.

Table 29 Summary of cost of Chyangli Low Land Tar

S.No.	Description of Works	Amount in NRs
A	Total Construction Cost	117,195,561.19
B	General Item	
	Insurance of works, equipment, contractor's workers and employees & Third party insurance against damage to other persons and property	1,000,000.00
	Preparation of as built Drawing	100,000.00
	Sub Total (B)	1,100,000.00
C	Contingencies	
	Work Charge (2.5% of A)	2,929,889.03
	Contingencies (2.5% of A)	2,929,889.03
	Physical Contingencies 10% of A	11,719,556.12
	Price Escalation Contingencies 10% of A	11,719,556.12
	Sub-total (C)	29,298,890.30
D	VAT (13% of A)	15,235,422.95
E	Provision for Environment Protection Cost	1,171,955.61
F	Total (A+B+C+D+E)	164,001,830.05
G	Cost per ha. (Total Cost)	488,100.68

222 Total cost of Chyangli Low land Tar with solar is also calculated and for this Tar the cost is NRs. 277,814,107 and with solar the cost per hectare is NRs. 8,26,827.The detail of cost estimate is given in Annex 14.

Table 30 Summary of cost of Aanpchaur Tar

S.No.	Description of Works	Amount in NRs
A	Total Construction Cost	50,074,562.33
B	General Item	
	Insurance of works, equipment, contractor's workers and employees & Third party insurance against damage to other persons and property	1,000,000.00
	Preparation of as built Drawing	100,000.00
	Sub Total (B)	1,100,000.00
C	Contingencies	
	Work Charge (2.5% of A)	1,251,864.06
	Contingencies (2.5% of A)	1,251,864.06
	Physical Contingencies 10% of A	5,007,456.23
	Price Escalation Contingencies 10% of A	5,007,456.23
	Sub-total (C)	12,518,640.58
D	VAT (13% of A)	6,509,693.10
E	Provision for Environment Protection Cost	1,001,491.25
F	Total (A+B+C+D+E)	71,204,387.26
G	Cost per ha. (Total Cost)	755,885.22

223 Total cost of Aanpchaur with solar is NRs.136, 707,856 and the cost per hectare with solar is NRs. 14, 51,251 (Annex 14).

Table 31 Summary of cost of Baireni (Kumaltari) Tar

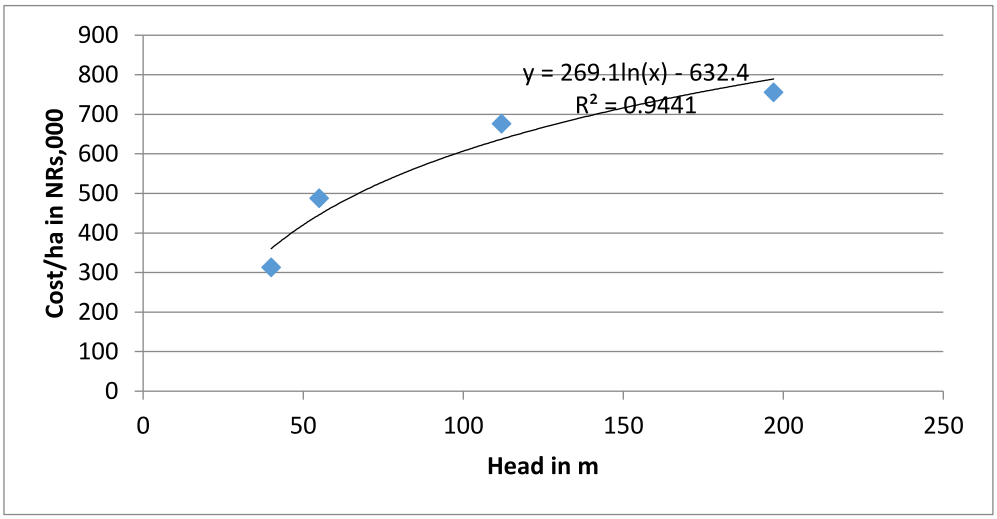
S.No.	Description of Works	Amount in NRs
A	Total Construction Cost	13,782,291.59
B	General Item	
	Insurance of works, equipment, contractor's workers and employees & Third party insurance against damage to other persons and property	1,000,000.00
	Preparation of as built Drawing	100,000.00
	Sub Total (B)	1,100,000.00
C	Contingencies	
	Work Charge (2.5% of A)	344,557.29
	Contingencies (2.5% of A)	344,557.29
	Physical Contingencies 10% of A	1,378,229.16
	Price Escalation Contingencies 10% of A	1,378,229.16
	Sub-total (C)	3,445,572.90
D	VAT (13% of A)	1,791,697.91
E	Provision for Environment Protection Cost	275,645.83
F	Total (A+B+C+D+E)	20,395,208.23
G	Cost per ha. (Total Cost)	313,194.23

224 Total cost of Baireni (Kumaltari) with solar is NRs.36, 771,075 and the cost per hectare with solar is NRs. 5, 64,666 (Annex 14).

225 Based on these cost estimates, a graph for head vs. cost per hectare without solar is obtained (Annex 14). This is presented below in Table 33. An equation, Cost per hectare, C=269.1 *ln(h)-632.4 (Equation 1) is also obtained, where ‘h’ is head in meter.

Table 32 Head vs. Cost per hectare graph without solar

Name of system	Head in m	Cost/ha in NRs,000
Baireni	40	313
Chyangli low	55	488
Chyangli High	112	676
Aanpchur	197	756



Graph 1 Head vs. Cost per ha Graph (without solar)

227 Thus obtained equation 1, is used to calculate the total project cost without solar for all the three clusters. This is given in Annex 14 in detail. It is shown below in Table 34.

Table 33 Total Cost of the Project without solar

Cluster Name	Name of the System	Gross command area, ha	Lifting Head m	Net CA, ha	Cost per ha =269.1(ln*h)-632.4) NRs.,000	Total cost NRs.,000	Total Cost - clusterwise, NRs.,000
Madi 1	Pathra Besi, Dulepani Kyamin 7	32	23	25.6	211.36	5,411	164,550
	Baireni (Kumaltari),Byas 5	81.4	40	65.12	313.19	20,395	
	Dui piple (Sisa ghat)	264.7	48	211.76	409.34	86,682	

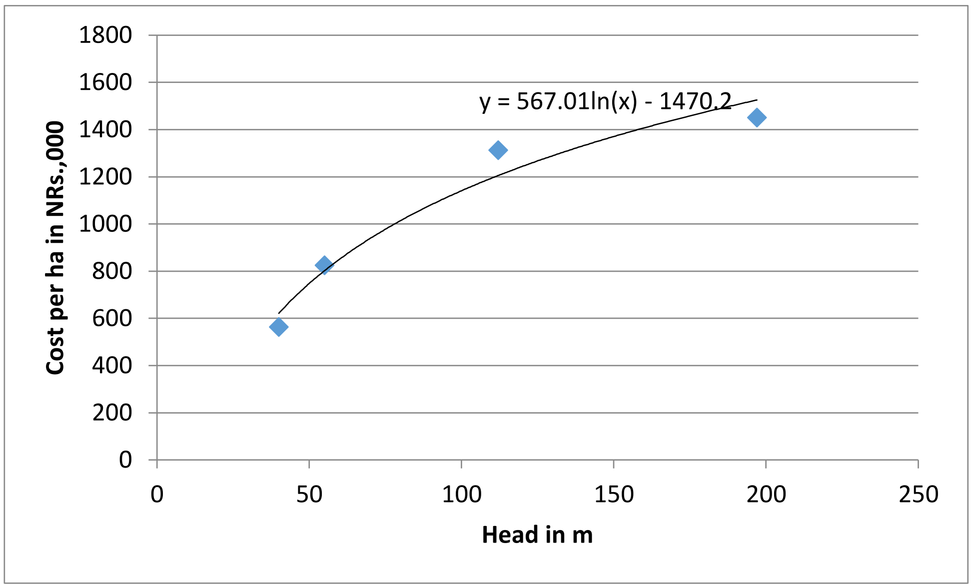
Cluster Name	Name of the System	Gross command area, ha	Lifting Head m	Net CA, ha	Cost per ha =269.1(ln*h)-632.4) NRs.,000	Total cost NRs.,000	Total Cost - clusterwise, NRs.,000
	Kalesti Botegaun, Kyamin 1	34.2	54	27.36	441.04	12,067	
	Kalesti phant, Kyamin 1	62.4	52	49.92	430.88	21,510	
	Satra saya phant (Sankhuli), Kyamin 7	46.3	67	37.04	499.08	18,486	
Marsyangdi 1	Chyangli lowland	420	55	336	488.10	164,002	261,390
	Chyangli Highland	180	112	144	676.31	97,389	
Kaligandaki 1	Bhalayatar 1	15.3	56	12.24	450.82	5,518	202,549
	Bhalayatar 2	50.5	54	40.4	441.04	17,818	
	Bhalayatar 3	46.5	54	37.2	441.04	16,407	
	Majhigaun, Chhap, Bojha,Hungi - 5	110.3	50	88.24	420.33	37,090	
	Bhujat, Rampur 13	16.5	45	13.2	391.97	5,174	
	Ekletar, Aanpchaur	91.6	45	73.28	391.97	28,724	
	Naugaun , Heklang	10	51	8	425.65	3,405	
	Tilakpur, Rampur 9	229	55	183.2	445.97	81,702	
	Ramtar, Shik danda , Rampur 15	16.3	71	13.04	514.69	6,712	
				1366		628,489	628,489

228 From this Table 34, the total cost of the project (all three clusters having 1366 hectares), is obtained as NRs.62, 84, 89,000.

229 Similarly head vs. cost per hectare graph with solar is drawn and this is shown in table 35. An equation- cost per hectare, C=567.01*ln(h) -1470.2 (equation 2) is obtained, where ‘h’ is head in meter.

Table 34 Head vs. Cost per hectare graph with solar

Name of system	Head in m	Cost/ha in NRs,000			
Baireni	40	564			
Chyangli low	55	826			
Chyangli High	112	1313			
Aanpchur	197	1451			



Graph 2 Head vs. Cost/ha in NRs, 000 (with solar)

230 This equation 2 is used to calculate the total project cost for all the three clusters with solar. This is given in Annex 14 in detail. It is shown below in Table 35. The total cost with solar is NRs.1, 121, 230,000.

Table 35 Total Cost of the Project with solar

Cluster Name	Name of the System	Gross command area, ha	Lifting Head m	Net CA, ha	Cost per ha =567.01(ln*h)-1470.2) NRs.,000	Total cost NRs.,000	Total Cost - clusterwise, NRs.,000
Madi 1	Pathra Besi, Dulepani Kyamin 7	32	23	25.6	307.66	7,876	292,090
	Baireni (Kumaltari),Byas 5	81.4	40	65.12	564.67	36,771	

Cluster Name	Name of the System	Gross command area, ha	Lifting Head m	Net CA, ha	Cost per ha =567.01(ln*h)-1470.2) NRs.,000	Total cost NRs.,000	Total Cost - clusterwise, NRs.,000
	Dui piple (Sisa ghat)	264.7	48	211.76	724.81	153,486	
	Kalesti Botegaun, Kyamin 1	34.2	54	27.36	791.59	21,658	
	Kalesti phant, Kyamin 1	62.4	52	49.92	770.19	38,448	
	Satra saya phant (Sankhuli), Kyamin 7	46.3	67	37.04	913.90	33,851	
Marsyangdi 1	Chyangli lowland	420	55	336	826.83	277,815	466,908
	Chyangli Highland	180	112	144	1313.15	189,094	
Kaligandaki 1	Bhalayatar 1	15.3	56	12.24	812.21	9,942	362,231
	Bhalayatar 2	50.5	54	40.4	791.59	31,980	
	Bhalayatar 3	46.5	54	37.2	791.59	29,447	
	Majhigaun, Chhap, Bojha,Hungi - 5	110.3	50	88.24	747.96	66,000	
	Bhujat, Rampur 13	16.5	45	13.2	688.22	9,084	
	Ekletar, Aanpchaur	91.6	45	73.28	688.22	50,432	
	Naugaun , Heklang	10	51	8	759.18	6,073	
	Tilakpur, Rampur 9	229	55	183.2	802.00	146,926	
	Ramtar, Shik danda , Rampur 15	16.3	71	13.04	946.78	12,346	
				1366		1,121,230	1,121,230

231 The cluster wise total cost of the project with or without solar is given in Table 36.

Table 36 Total Cost of the Project cluster wise (with or without solar)

Cluster Name	Gross command area, ha	Net CA, ha	Total Cost -clusterwise, NRs.,000
Without Solar			
Madi 1	521	417	164,550
Marsyangdi 1	600	480	261,390
Kaligandaki 1	586	469	202,549
Total	**1707**	**1366**	**628,489**
With Solar			
Madi 1	521	417	292,090

Cluster Name	Gross command area, ha	Net CA, ha	Total Cost -clusterwise, NRs.,000
Marsyangdi 1	600	480	466,908
Kaligandaki 1	586	469	362,231
Total	**1707**	**1366**	**1,121,230**

11.3 Estimated Benefits

11.3.1 Agricultural Benefit

232 Incremental benefits from the project are calculated based on the existing cropping practices and proposed agricultural development plan. The agricultural benefit depends upon the cropping pattern to be followed suitable with the new irrigation technology. In most cases, vegetable farming is proposed in winter and spring season with paddy in monsoon.

11.3.2 Increase in Employment Opportunity

233 With the introduction of vegetable farming, there will be significant increase in employment opportunities for the rural populace. Employment is generated for collection, transportation and distribution of agricultural products.

11.3.3 Involvement of Women in Irrigation

234 Vegetable farming is labor intensive requiring comparatively light work although the working hours may be long and therefore very suitable for women farmers. Women can easily perform all related activities such as transplanting, de-weeding, watering, and harvesting. It is because of this that the proposed irrigation development in the river terraces will provide ample opportunity for women in irrigated farming along with other indirect employment opportunities resulting from the intensification of agriculture and its increased farm products.

11.4 Economic Analysis

235 The economic analysis is carried out considering the following assumptions.

- Life of the project is taken as 30 years,
- The construction cost of the system is converted to its economic cost by multiplying with a conversion factor of 0.95 and for operation and maintenance cost the conversion factor is taken as 0.90
- The construction cost is distributed over three consecutive years,
- The agricultural benefit is calculated with proposed cropping pattern and it is assumed that farmers will follow the suggested cropping patterns.

- Major overhauling cost is included in 11th year of life of the project.

236 Based on these assumptions, the economic analysis of the project was carried out and results of economic indicators are presented in Table 29. The benefit cost ratio is computed for a 12 percent discount rate. The details of economic analysis are attached in Annex 15 and 16.

237 Benefit Cost analysis is carried out for the following systems- ,Madinadi1, Marsyangdi1 (Chyangli high land and Chyangli Low land), and Kaligandaki 1 and the whole project. For analysis, the costs are taken with or without solar power condition.

238 Sensitivity Analysis is also done on the following cases:

- Cost increased by 20% other factors remaining same.
- Benefit decreased by 20% other factors remaining same.
- Cost increased by 20% and Benefit decreased by 20% other factors remaining same.
- With use of Solar power

239 The economic indicators are given in Tables 37-41. The details of economic analyses are attached in Annex 15 and 16.

Table 37 Economic Indicators of Mid Hill Lift Irrigation Project

S.N	Cases	Economic Indicators	
		Benefit-Cost Ratio	EIRR (%)
1	Normal Case	3.69	35.63%
2	Cost increased by 20% other factors remaining same.	3.02	30.73%
3	Benefit decreased by 20% other factors remaining same.	2.95	30.45%
4	Cost increased by 20% and Benefit decreased by 20% other factors remaining same	2.46	26.62%
5	Project with solar	2.06	23.24%

Table 38 Economic indicators for Madi-1

S.N	Cases	Economic Indicators	
		Benefit-Cost Ratio	EIRR (%)
1	Normal Case	4.12	38.41%
2	Cost increased by 20% other factors remaining same.	3.37	33.23%

S.N	Cases	Economic Indicators	
		Benefit-Cost Ratio	EIRR (%)
3	Benefit decreased by 20% other factors remaining same.	3.3	32.95%
4	Cost increased by 20% and Benefit decreased by 20% other factors remaining same	2.75	28.90%
5	Project with solar	2.32	25.48%

Table 39 Economic indicators for Chyangli Highland

S.N	Cases	Economic Indicators	
		Benefit-Cost Ratio	EIRR (%)
1	Normal Case	2.46	26.62%
2	Cost increased by 20% other factors remaining same.	2.01	22.66%
3	Benefit decreased by 20% other factors remaining same.	1.97	22.38%
4	Cost increased by 20% and Benefit decreased by 20% other factors remaining same	1.64	19.24%
5	Project with solar	1.27	15.26%

Table 40 Economic indicators for Chyangli low land

S.N	Cases	Economic Indicators	
		Benefit-Cost Ratio	EIRR (%)
1	Normal Case	2.12	23.75%
2	Cost increased by 20% other factors remaining same.	1.73	20.09%
3	Benefit decreased by 20% other factors remaining same.	1.7	19.80%
4	Cost increased by 20% and Benefit decreased by 20% other factors remaining same	1.41	16.89%
5	Project with solar	1.19	14.33%

Table 41 Economic indicators for Kaligandaki-1

S.N	Cases	Economic Indicators	
		Benefit-Cost Ratio	EIRR (%)
1	Normal Case	3.69	35.63%
2	Cost increased by 20% other factors remaining same.	3.02	30.73%
3	Benefit decreased by 20% other factors remaining same.	2.95	30.45%
4	Cost increased by 20% and Benefit decreased by 20% other factors remaining same	2.46	26.62%
5	Project with solar	2.06	23.24%

240 Thus from the factors indicated in the above table, we can see that the project is economically viable.

12.0 CONCLUSIONS AND RECOMMENDATIONS

12.1 Conclusions

241 The Pre-feasibility Study of Kaligandaki, Marsyangdi, Madinadi River Terraces in Palpa, Gorkha, Tanahun, and Lamjung districts have been carried out along the river banks and the study leads to the following conclusions:

- ✓ The proposed project is environmentally friendly and use water for irrigation efficiently.
- ✓ Farmers of the project area have shown their keen interest for the implementation of the project and to participate as per requirement of Government Policy.
- ✓ The proposed lift irrigation projects are socially viable and could serve well for the enhancement of the living standards of farmers including marginal communities like Kumal, Kami, Damai, Bote , Majhi etc.

12.2 Recommendations

242 Based on the findings of the field survey, engineering design and estimation, economic analysis of the proposed model projects, and socio-environmental considerations, the following recommendations have been made.

- ✓ The implementation of these model clusters are justified by both technical and economic considerations.
- ✓ It is recommended to go for Detail Feasibility Study for these three clusters.

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ANNEXES

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